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ELECTRICAL SECTION.

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ELECTROCHEMICAL ACTION.

BY C. J. REED, Member of the Institute.

(*Continued from p. 393.*)

POLARIZATION.

The *polarization* of an electrochemical cell may be defined as *electrochemical fatigue*. It is caused by the exhaustion of the reagents at the loci of electrochemical action (terminals of the electrolyte or electrolytic chain) and their consequent replacement by other substances, which produce a different and more electrothanic or less electrogenic reaction.

Reverting again to the typical electrochemical cell, such as that shown in *Fig. 4*, having as electrolytes copper sulphate, and as electrodes sheets of copper, it is evident from the local nature of electrochemical action that, if there is no mechanical movement of the electrodes or the electrolyte,

the very thin layer of reagents at the surface of reaction, having a thickness of only a single layer of molecules, will be exhausted as soon as the current corresponding to the quantity of material in that layer of molecules has passed through the cell. When this condition ensues, electrochemical action must cease, unless other reagents are present to act as substitutes for the exhausted material. If other reagents are present, the electromotive force is altered to correspond to their chemical energy. These reagents in turn become likewise exhausted. This exhaustion in most cells of ordinary dimensions would be produced by a very minute current in an exceedingly short time, and before any visible deflection of a galvanometer needle could be produced, if the components of the system were devoid of motion. Either internal mechanical motion of the electrolyte or its particles with reference to the electrodes, or the continuous shifting of the plane of reaction is, therefore, a necessary condition of continuous electrochemical action, except where the active surfaces are of enormous dimensions.

Fortunately we have an agency capable of producing and maintaining this motion, which is always necessarily present in all electrolytes. This agency is *diffusion* and is due, as is well known, to mutual repulsion of the similar particles of a liquid or gas, in virtue of which such particles tend to become uniformly distributed throughout the volume, to which they have access. Let us suppose that in the electrochemical system represented in *Fig. 4* we have an electrolyte consisting of a uniform mixture of particles of water and copper sulphate in any proportion and two electrodes of metallic copper, electrically connected by a copper wire which completes the circuit. The particles of copper sulphate and also those of the water are in a condition of physical equilibrium and uniform distribution. The system is also in a state of electrical equilibrium. Each electrode tends to dissolve in the electrolyte and produce an electromotive force of 1·21 volts. But these electromotive forces are in opposite directions and there is, consequently, a perfect electrical equilibrium. When an electromotive force

from an external source is established in this circuit, tending to send a current through the cell in either direction, it acts upon this balanced system of electromotive forces in the cell in the same manner as the slightest mechanical force, applied to a perfectly balanced scale beam, which causes one end of the beam to move up and the other end to move down without in any way increasing or diminishing the potential energy of the beam itself. In like manner the external electromotive force, applied to this balanced electrochemical system, causes copper to move into solution from one electrode and an equal quantity to move out of solution upon the other electrode. The dissolving of copper from the electrode C' into solution is accompanied by a loss of chemical energy at that electrode, exactly as the downward movement of one end of a balanced beam is accompanied by a loss of energy of position at that end. The movement of copper out of solution and its deposition in the metallic state upon the other electrode is accompanied by an equal accumulation there of chemical energy, exactly as the upward motion of the opposite end of the balanced beam is accompanied by an accumulation of energy of position in that part of the system. In both cases energy has been transferred through the transfer of matter from one part of the system to another part of the same system. This transfer of matter requires the expenditure of a small quantity of energy from an external source, which is dissipated as heat; but in neither case has the energy of the system itself been altered. The potential energy of the one system is the same in the initial and in all succeeding states. So also the chemical energy of the other system is the same in the initial and in all succeeding states.

It is found in this case that there results from the passage of the current, not only the disappearance of copper from C', but also a disappearance of $CuSO_4$ from the surface of C and an accumulation of $CuSO_4$ at the surface of C'. That is, $CuSO_4$ is apparently transported simultaneously with the copper, but in the opposite direction. At the surface, C', where copper disappears, an equivalent of $CuSO^4$ appears, and at the surface, C, where copper appears, an

equivalent of $CuSO_4$ disappears. It is evident, therefore, that after the current has passed, we have no longer a uniform distribution of $CuSO_4$. It is becoming weaker at C and stronger at C'. When the $CuSO_4$ at C is exhausted to such an extent that there are no longer enough molecules to transmit the entire current, the current can be maintained only by increasing the electromotive force, until it is sufficient to decompose the water. This condition, produced by exhaustion of a reagent and resulting in an increase of the electrothanic power or a decrease of the electrogenic power of an electrochemical system, is "polarization."

This removal of $CuSO_4$ from the space adjacent to the electrode, C, on which the copper is deposited, results in an enormous osmotic pressure and a motion of the particles of copper sulphate towards the exhausted region. When the exhaustion extends only to molecular distances from the terminal surface, the re-distribution is practically instantaneous and is produced at a rate proportional to the osmotic pressure, which is proportional to the difference in concentration of the copper sulphate at any two points.

The process of diffusion and re-distribution begins immediately after the equilibrium is disturbed, and, therefore, with solutions of considerable density and with a moderate current (speed of electrochemical reaction), the re-distribution keeps pace with the progress of exhaustion, so that a continuous current may be obtained through the cell without increasing the electromotive force to the point required to decompose the water present. If, however, the motion of the electrolyte is only that due to diffusion, and if the electrochemical action is rapid, partial exhaustion will finally ensue for a considerable distance from the electrode.

When exhaustion proceeds so far that the osmotic pressure can no longer transport the copper sulphate through the exhausted region as rapidly as it is being removed from the surface of the electrode, the strength of the current must be reduced to correspond with the quantity of copper sulphate supplied per unit of time by diffusion to the surface. Whenever the strength of the current is allowed to

exceed this limit, it is evident that water, the other component of the mixture, must suffer decomposition and hydrogen must be deposited. This cannot occur, however, until the impressed electromotive force has attained a value equal to 1·48 — 1·21 = 0·27 volt. We see, therefore, that the fatigue of this cell, or exhaustion of the copper sulphate at the cathode, causes the water, a more electrothanic substance, to take its place in the electrochemical reaction and suffer decomposition. In other words, polarization of this cell results in the formation of hydrogen at the cathode.

The dependence of continuous electrochemical action upon diffusion, as here stated, can be experimentally observed only when all other sources of motion are eliminated. In the cell described, this is practically possible only when the cathode is in the form of a flat, horizontal surface suspended at the top of the solution, and the anode a flat horizontal surface at the bottom of the solution. Otherwise, the changes in the density of the solution, produced at the electrodes by the elimination of copper at the cathode and its introduction at the anode, immediately cause convection currents, which bring fresh portions of $CuSO_4$ to the cathode and water to the anode. In all ordinary cases of electrolysis this convection is the principal cause of the transportation of matter to and from the electrodes.

Polarization, or exhaustion, is not limited to the cathode, but may also occur at the anode in a manner exactly similar, if two or more reagents are present at the anode and are equally accessible to the electrochemical circuit.

If several independent electrothans are simultaneously present at an electrode of an active electrochemical cell, and are all equally accessible to the circuit, it is evident that the one absorbing the least electrical energy will be the first to undergo electrochemical action and exhaustion. If this substance is not renewed by circulation, diffusion or otherwise, in sufficient quantity to transmit the total current, the other electrothans present will be successively exhausted in the order of their increasing electrothanic power.

In like manner, when several independent electrogens are

simultaneously present at an electrode of an active electrochemical cell, the one supplying the greatest electrical energy will be the first to undergo electrochemical action and exhaustion, and the other electrogens present will be successively exhausted in the order of their decreasing electrogenic power. Thus, potassium would be used up before zinc, zinc before copper, and copper before mercury, when all of these substances are present and equally accessible at the anode of an electrochemical system, having an electrolyte of dilute sulphuric acid.

Any case of polarization is rationally explainable as due to two causes: (1) exhaustion, and (2) the operation of a general law, which we may call the *law of maximum electrogenesis.* It may be stated as follows:

When two or more independent electrogens in the same electrochemical system are equally accessible in parallel to the electrochemical circuit, they are successively exhausted in their order of maximum electrogenic power; and when two or more independent electrothans in the same system are equally accessible in parallel to the same electrochemical circuit, they are successively exhausted in their order of minimum electrothanic power.

The law may also be stated in the following form:

When several independent electrochemical reactions in the same system are equally accessible in parallel to the same electrochemical circuit, they are successively exhausted in their order of maximum evolution or minimum absorption of electrical energy.

According to this law the evolution of electrical energy in the discharge of a galvanic battery tends to be a maximum and the absorption of electrical energy in the charging of an accumulator tends to be a minimum. It is this law that causes zinc to be dissolved before iron, and iron before copper, when all three are in contact in dilute acids. It also causes lead peroxide to be reduced to the monoxide before the monoxide is reduced to the metallic state. The successful electrolytic separation of metals depends entirely upon intelligent obedience to this law. But perhaps the most important result of this law is that it requires that an electrogenic system (a galvanic battery or a charged accumulator) shall run down or discharge itself automatically,

whenever there is an exit for the electrical energy, that is, whenever the electrochemical circuit is completed by a conductor or series of conductors which does not include a source of counter-electromotive force equal to or greater than the electrogenic power of the system.

It is for this reason that a galvanic battery or charged accumulator never requires an external force or agency to *start it* into action. No electrochemical system, unless it is of itself electrogenic, and capable of starting automatically, can be converted into a source of electrical energy by any process of *starting*. And no electrogenic system requires any starting process to set it into action. The closing of the circuit and the maintenance of other physical conditions necessary for electrochemical action are the only requisites. Every chemical reaction requires, for example, that the materials shall be maintained within a certain range of temperatures. But the process of bringing a system into conditions under which electrochemical action is possible, never renders a system electrogenic which was not previously electrogenic. The mere heating of a system of chemical reagents does not impart to it a power of evolving any chemical energy, except that which it previously possessed. All energy absorbed by a system, and used in raising its temperature, can be evolved again only when the system loses its temperature. It is true that additional heat, besides that required to raise the temperature of a system, may be absorbed by the system and simultaneously converted into electrical energy. Electrical energy developed by such a process, however, evidently does not come from the chemical energy of the system, but from thermo-electric inversion.

Many futile attempts have been made to form an electrogenic or galvanic cell by oxidizing carbon in electrochemical reactions which absorb energy, on the supposition that such an action, when once started by the application of an electric current from an external source, would become a source of electrical energy. The reason for the inevitable failure of such devices is apparent. If there is any possibility of obtaining electrical energy from the oxidation of

carbon in an electrochemical cell, it must, at least, be accomplished by an electrochemical reaction that evolves energy.

As already stated, polarization is not a peculiarity of the cathode. Being a condition produced by exhaustion of material, it may occur as easily at one terminal of the electrolyte as at the other. In most galvanic batteries metallic zinc is the anode and, at the same time, the reagent that undergoes exhaustion; but it is generally present in so great an excess that polarization due to exhaustion of zinc does not occur. As this reagent constitutes the electrode itself, it requires no diffusion or other motion to transport it to the surface of reaction, but is accessible as long as it lasts. If, however, the zinc of an ordinary battery were supported on a framework of cadmium, copper, or lead, the electromotive force of the cell would correspond to the electrogenic power of the zinc until the zinc is exhausted. After that the electromotive force would decrease to that corresponding to the electrogenic power of the metal forming the framework, which would act as a substitute for the zinc. This would be a case of polarization at the anode, exactly similar to that of exhaustion at the cathode, except that the reagents are solid metals instead of solutions. In the polarization of a lead accumulator by discharge, the reagents are in part solid and in part liquid at both electrodes and the exhaustion occurs at the anode and cathode alike.

When zinc containing copper and other electro-negative metals as impurities is used in a galvanic cell, the impurity is left on the surface of the zinc and soon acts as a substitute for the zinc, reducing the electromotive force of the cell to correspond to the electrogenic power of the copper or other impurity. The impurity at the same time generally forms a local electrochemical system with the zinc, causing it to be rapidly dissolved and its energy to be dissipated in heat through the Joule effect of the local circuit.

In consequence of the popular belief that polarization can occur only at the cathode, the reagents used at that terminal have received the name of "depolarizers," because, as we shall see later, while these reagents last, there is no polarization. In all electrochemical systems

these cathode reagents, or depolarizers, are invariably what are chemically known as "oxidizing agents," or, more broadly speaking, *they are chemical compounds, one or more components of which suffer diminution of chemical valence in an electrochemical reaction, or they are chemical elements whose valence becomes electro-negative in an electrochemical reaction.* The anode reagents of an electrochemical system (substances that undergo exhaustion at the anode) are invariably "reducing agents," that is, *substances, whose chemical valence suffers an increase or whose electro-negative valence becomes zero or positive.*

Speed of Electrochemical Action.—The rate at which electrochemical action may proceed without the disturbance due to polarization is evidently proportional to the area of the surface of contact between the electrode and the electrolyte, since the quantity of material available at any time is proportional to the extent of the layer of molecules constituting that surface.

The surface exposed to electrochemical action by metals in the ordinary condition is very small, while that exposed by a metal in a finely divided but coherent mass is comparatively enormous. The fact that very large electric currents may be taken from lead accumulators of small dimensions, with slight polarization, is due to the great surface exposure at both terminals of the electrolyte. Here the surfaces of the finely divided lead and lead peroxide, which are bathed in the electrolyte, may be compared to the surface of the leaves of a tree or of a field of moss. We may say in this case that the entire available mass of active material is spread out in a layer of almost molecular tenuity. Such an electrochemical system could give up all of its available energy in an instant without polarization on closing the circuit, if the system had no resistance to limit the current to a certain maximum, and if a sufficient amount of sulphuric acid to unite with all of the available lead and lead peroxide could be contained at one time within the pores of the spongy solids and in contact with their surfaces. But the solution generally used in accumulators contains only about one molecule of acid to twenty-five of

water, so that not more than one twenty-fifth part of the surface can at any instant be in contact with the acid, and diffusion must act, as in all other electrochemical cells, to bring more acid to the terminal surfaces as it is consumed, and also to bring more acid into the spongy mass from without.

Fig. 7 represents, on a greatly magnified scale, a portion of an electrode of a lead accumulator and its adjacent electrolyte. The dark bands may be supposed to represent either filaments of spongy lead or crystals of lead peroxide,

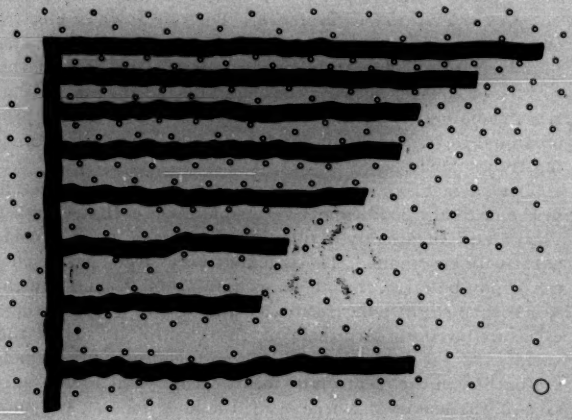

FIG. 7.

and the small circles to represent molecules of H_2SO_4 diffused through the solution. It is apparent that only a small portion of the surface of the electrode is in contact with the molecules of acid. It is also apparent that the spaces between the filaments of lead cannot at one time contain a sufficient number of molecules of acid to cover the entire surface. Before the acid contained in these spaces is consumed, more must pass into the pores of the plate, in order to maintain electrochemical action without polarization.

From the fact that electrochemical action can take place only at the bounding surface of the electrolyte, it follows that all electrodes must be solids or else liquids that do not mix or diffuse through the electrolyte. Otherwise, distinct surfaces of separation would be impossible. Practically we find that all known electrodes are either solids or molten metals or alloys.

An electrode may or may not be one of the electrochemical reagents. The carbon electrode of the Bunsen cell and the copper electrode of the Daniell cell take no part in the electrochemical action, being merely conductors. As conductors they should be mutually interchangeable without affecting the electromotive force of the cell. Carbon may be substituted for the copper of the Daniell cell, but copper cannot be substituted for the carbon of the Bunsen cell, because the copper would be acted upon by the nitric acid.

An interesting series of experiments illustrating this statement is obtained by substituting in the Bunsen cell various metallic electrodes instead of the carbon. A rod of aluminum, for example, substituted for the carbon, gives nearly the same electromotive force as that given by the carbon, though aluminum in sulphuric acid is more highly electro-positive than zinc.* The explanation is very simple. The nitric acid in the Bunsen cell is the electrothanic reagent which undergoes electrochemical action at the carbon electrode, while the electrode itself acts only as a conductor. Therefore, any conductor not chemically acted upon by the nitric acid may be substituted for the carbon without changing the chemical reaction and, hence, without changing the electromotive force. Aluminum happens to be a metal that is not acted upon by nitric acid, and it may, therefore, be used instead of the carbon. By substituting aluminum for both the carbon and the zinc, 1·5 volts may be obtained. We may even replace the carbon by aluminum and the zinc by a more electro-negative metal, such as

* To show that aluminum is electropositive to zinc, both metals should be well amalgamated to remove the influence of impurities, but the aluminum should not be amalgamated when substituted for carbon in the Bunsen battery, as the mercury would be rapidly dissolved.

iron, cadmium, copper, nickel, silver, or mercury, without changing the direction of the electromotive force. It may seem remarkable that we can exchange for the highly electro-negative carbon electrode the highly electro-positive metal, aluminum, and at the same time replace the highly electro-positive zinc electrode by one of a metal so highly electro-negative as copper or silver, without reversing the electromotive force of the cell. But experiment proves and the electrogenic powers of the electrochemical reactions involved require these facts. With this arrangement the following results were obtained experimentally:

Al	HNO_3	H_2SO_4	Zn	1·73 volts.
"	"	"	Cd	1·422 "
"	"	"	Fe	·99 volt
"	"	"	Cu	·66 "
"	"	"	Ni	·64 "
"	"	"	Ag	·40 "
"	"	"	Hg	·305 "
"	"	"	Pb	1·20 volts

These facts corroborate other proofs that the electromotive force of a galvanic cell is not due to the mere "contact" of metals and electrolytes, but to the chemical energy of the electrochemical reaction.

It is evident from the nature of polarization, as defined above and as found practically in all electrochemical cells, whether electrothanic or electrogenic, that the speed of continuous electrochemical action without polarization may generally be materially increased by imparting a rapid mechanical motion to the electrolytes to assist diffusion. We do not mean that the two electrolytes are to be mixed together, but that each electrolyte is to be kept in motion, while the two are separated by a porous wall, except where both electrolytes are of the same material.

Although diffusion is practically instantaneous at molecular distances, it requires considerable time to act at measurable distances, the time being proportional to the square of the distance.

Clogging of Electrodes.—Continuous electrochemical action requires also that the terminals of the electrolyte shall not

be clogged by the products of the reaction. When these products are soluble in the electrolyte, they are rapidly removed by diffusion and mechanical motion, as is the case with the chloride, sulphate, and other salts of zinc. When one of the products of the reaction is a metal or other conducting solid, set free at the electrode, the surface of the electrode is shifted into another plane, the deposited product of the reaction itself becoming the surface of the electrode. This is illustrated in the deposition of copper on the cathode of the copper-zinc cell. But in the lead accumulator the product of the reaction is an insoluble lead sulphate at both terminals, which remains permanently between the electrode and the electrolyte, completely obstructing any further action. In this case the reaction can proceed only until the entire surface of the electrode has undergone chemical change. In such a battery, as already pointed out, the entire mass of available active reagent must be spread out so as to constitute the surface of the electrode.

[*To be concluded.*]

ANTARCTICA: A HISTORY OF ANTARCTIC DISCOVERY.*

By Edwin Swift Balch.

(*Continued from p. 341.*)

In 1839 and 1840 Lieutenant Wilkes made a second cruise to the Antarctic, in accordance with his Instructions from the Hon. J. K. Paulding, Secretary of the Navy, which were as follows:†

"Navy Department, August 11th, 1838.

"These objects will, it is presumed, occupy you until the latter end of October; and when attained as far as may be possible, you will proceed to the port of Sydney, where adequate supplies may be obtained. From thence you will

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†"Narrative U. S. E. E.," Vol. I, p. 27.

make a second attempt to penetrate within the Antarctic region, south of Van Diemen's Land, and as far west as longitude 45° E., or to Enderby's Land, making your rendezvous on your return at Kerguelen's Land, or the Isle of Desolation, as it is now usually denominated, and where you will probably arrive by the latter end of March, 1840."

Wilkes' squadron was composed of the sloop of war "Vincennes," 780 tons, under his own command; the sloop of war "Peacock," 650 tons, Commander William L. Hudson; the gun brig "Porpoise," 230 tons, Lieutenant Commander Cadwalader Ringgold; and the pilot boat "Flying Fish," 96 tons, Lieutenant R. F. Pinkney. None of these vessels was suitable for ice work, nor was the expedition properly equipped, for* it "may be borne in mind that our vessels had no planking, extra fastening, or other preparations for these icy regions, beyond those of the vessels of war in our service." The people at Sydney† "inquired whether we had compartments in our ships to prevent us from sinking? How we intended to keep ourselves warm? What kind of antiscorbutic we were going to use? and where were our great ice saws? To all these questions I was obliged to answer, to their great apparent surprise, that we had none, and to agree with them that we were unwise to attempt such service in ordinary cruising vessels; but we had been ordered to go, and that was enough, and go we should. * * * The tender "Flying Fish" excited their astonishment more than the ships, from her smallness and peculiar rig; and, altogether, as a gentleman told me, most of our visitors considered us doomed to be frozen to death. I did not anticipate such a fate, although I confess I felt the chances were much against us, in case we were compelled to winter within the Antarctic. From every calculation we could not stow twelve months' provision, even upon short allowance; our fuel was inadequate to last us more than seven months, and the means of protecting ourselves in the ships for winter quarters, were anything but suffi-

* Wilkes: "Narrative U. S. E. E.," Vol. II, p. 298.
† Wilkes: "Narrative U. S. E. E.," Vol. II, p. 275.

cient. The "Peacock"* was in especially bad condition, for her sheer-streak, to which the channels were bolted and ports hung, was perfectly decayed, fore and aft, and all the stanchions of the upper deck bulwarks were either rotten or in an advanced state of decay. It was, therefore, with unsuitable ships, improperly equipped, that Wilkes started on the cruise which resulted in the great discovery, that in one part of the Antarctic there is a mass of land of sufficient extent to be probably ranked as a continent.

The expedition started from Sydney on December 26, 1839. The tender "Flying Fish" parted company with it on January 1, 1840, and cruised by itself.† On the 21st it made the icy barrier in 65° 20′ south latitude, 159° 36′ east longitude. On the 23d, in 65° 58′ south latitude, 157° 49′ east longitude, they discovered several dark spots, which they made out to be rocks. After this they cruised along the ice barrier until February 5th, when they were in 66° south latitude, 143° east longitude, and were forced to return north on account of sickness.

After parting company with the "Flying Fish," the other ships continued their course south, and on January 7, 1840, were in 54° 20′ south latitude, and 160° 47′ east longitude, not far from Macquarie Island. On the 10th they encountered the first iceberg. On the 11th, at 10.30 P.M., in 60° 11′ south latitude, 164° 36′ east longitude, they were stopped by a compact barrier of ice, enclosing large square icebergs. The water changed to an olive green color. On the 13th, in 65° 8′ south latitude, 163° east longitude, they came up to an icy barrier. "Very lofty ridges of ice,‡ and the loom usual over high land, were visible along the southern horizon, over the barrier. * * * From appearances to the southward, with the numerous *Phocae proboscidae*, I

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*Letters of Mr. Dibble, carpenter, and Captain Hudson: "Narrative U. S. E. E.," Vol. II, p. 449.

†"Narrative U. S. E. E.," Vol. II, pp. 354-359.

‡ Ringgold's Report: "Narrative U. S. E. E.," Vol. II, p. 469.

was strongly impressed with the belief of the close approach of land."*

"On the 16th † the three vessels were in longitude 157° 46′ E., and all within a short distance of each other. * * * On this day (16th of January) appearances believed at the time to be land, were visible from all the vessels, and the comparison of the three observations, when taken in connection with the more positive proofs of its existence afterwards obtained, has left no doubt that the appearance was not deceptive. From this date, therefore, we date the discovery which is claimed for the squadron. * * * On board the 'Peacock,' it appears that Passed Midshipmen Eld and Reynolds both saw the land from the masthead, and reported it to Captain Hudson; he was well satisfied on examination that the appearance was totally distinct from that of ice islands, and a majority of the officers and men were also satisfied that if land could exist, that was it. * * * In Passed Midshipman Eld's journal, he asserts that he had been several times to the masthead during the day, to view the barrier; that it was not only a barrier of ice, but one of terra firma. Passed Midshipman Reynolds and himself, exclaimed with one accord that it was land. Not trusting to the naked eye, they descended for spy-glasses, which confirmed, beyond a doubt, their first impression. The mountains could be distinctly seen, over the field ice and bergs, stretching to the southwest as far as anything could be discerned. Two peaks in particular, were very distinct (which I have named after those two officers), rising in a conical form; and others, the lower parts of which were as distinct, but whose summits were lost in light fleecy clouds. Few clouds were to be seen in any other direction, for the weather was remarkably clear. The sun shone brightly on

* The Balleny Islands are about 1½° of latitude south of the spot where the "Porpoise" was on January 13. It is therefore probable that "the loom usual over high land" was caused by them. I notice that Mr. Borchgrevink, *Geographical Journal*, Vol. XVI, October, 1900, p. 381, appears to be of this opinion, for he says: "I had, however, purposely taken that course in order to satisfy myself respecting the land reported by Captain Wilkes, and which, it seems clear to me, was, in reality, Balleny."

† Wilkes: "Narrative U. S. E. E.," Vol. II, pp. 292, 293.

ridge after ridge, whose sides were partially bare; these connected the eminences I have just spoken of, which must be from one to two thousand feet high. Mr. Eld further states, that on reporting the discovery to Captain Hudson, the latter replied that there was no doubt of it, and that he believed that most of the icebergs then in sight were aground. At this time they were close in with the barrier and could approach no nearer. On this day the 'Peacock' got a cast of the deep-sea lead, with Six's thermometer attached, to the depth of eight hundred and fifty fathoms, only a short distance from the barrier; the temperature of the surface was 31°, and at the depth sounded, 31½°, current one fourth of a mile, north by east."

"On the evening of the 16th,* strong appearances of land again arose, in corroboration of which I insert an extract from my journal, as well as the remarks from the log-book. * * * Extract from Journal. 'At 6 h. 30 m. P.M. I went aloft to take a look, the weather being clear, horizon good and clouds lofty. I heard the noise of a penguin; soon after, one was seen very near the brig, with a large seal to windward. After reaching masthead, I saw over the field of ice, an object, large, dark and rounding, resembling a mountain in the distance. The icebergs all were bright and brilliant, and in great contrast. * * * I watched for an hour to see if the sun in his decline would change the colour of the object by a difference of rays; it remained the same, with a white cloud above, similar to those generally hovering over high lands; at sunset it remained the same. I took the bearing accurately, intending to examine it closely as soon as I got a breeze. I am strongly of the opinion it is an island, surrounded by immense fields of ice now in sight.' * * * Extract from Log. 'At 7 P.M. discovered what was supposed to be an island, bearing south-by-east—a great deal of field-ice in sight. (Signed) J. H. North. * * * 17th, the indications were again noticed, corroborating those of the day preceding.'

* Ringgold's Report: "Narrative U. S. E. E.," Vol. II, pp. 469, 470.

"On the morning of the 19th * we found ourselves in a deep bay, and discovered the 'Peacock' standing to the southwest. Until eight o'clock A.M. we had a moderate breeze. The water was of a darker olive-green, and had a muddy appearance. Land was certainly visible from the 'Vincennes,' both to the south-southeast and southwest, in the former direction most distinctly. Both appeared high. It was between eight and nine in the morning when I was fully satisfied that it was certainly land, and my own opinion was confirmed by that of some of the oldest and most experienced seamen on board. The officer of the morning watch, Lieutenant Alden, sent twice and called my attention to it. We were at this time in longitude 154° 30′ E., latitude 66° 20′ S., the day was fine, and at times quite clear, with ligh winds. After divine service, I still saw the outline of the land, unchanged in form but not so distinct as in the morning. By noon, I found we were sagging on to the barrier; the boats were lowered in consequence, and the ship towed off. The report from aloft was, 'A continued barrier of ice around the bay, and no opening to be seen, having the western point of it bearing to the northward of west of us.' I stood to the westward to pass around it, fully assured that the 'Peacock' would explore all the outline of the bay."

"On Sunday, January 19th,† while standing into a bay of ice, in latitude 66° 31′ S., and longitude 153° 40′ E., we made (what we believed to be) land to the southward and westward. * * * It was seen towering above and beyond some large icebergs, that were from one hundred to one hundred and fifty feet in height. We endeavored to work up for this land, which presented the appearance of an immense mass of snow, apparently forming a vast amphitheatre, with two distinct ridges or elevations throughout its extent. After working until midnight through detached portions of ice, we reached the barrier at the head of the bay, and were compelled to give up any further attempt to

* Wilkes: "Narrative U. S. E. E," Vol., II, page 295.

† Hudson's Report: "Narrative U. S. E. E.," Vol. II, page 465.

near it (what we believed to be land), and passed out of the bay again, which was some twenty miles in extent, through drift-ice into a more open space for pursuing our course to the southward and westward along the barrier."

"On the 22d, 4 A.M.,* appearances of land again to the southward and eastward, at the time passing an iceberg with dark veins and dusty appearances, exciting confident hopes of soon making positive discoveries."

"On the 23rd † of January we made, beyond the barrier, which was thickly studded with bergs and islands of ice, (what we believed to be,) high land, at least so far as terra firma can be distinguished where everything is covered with snow, and worked into a bay for a nearer and more minute examination. The sea water had been discoloured for some days, but no bottom obtained by soundings; in the bay, however, it changed to a dark dull green, and gave every indication that we were on soundings, and not far from land. * * * The result confirmed the appearances: we obtained bottom in three hundred and twenty fathoms, of slate-coloured mud, and the lead brought up with it a piece of stone, about an inch in length, of nearly the same colour, while the lower part of the lead showed a fresh and deep indentation, as though it had struck on a rock. Dip observations were made on the ice with Robinson's and Lloyd's needles; the former gave 86·10,° the latter 86·23°. While ascertaining the dip, a large king-penguin was captured on the ice, and brought to the ship; to add to our collections, in his stomach were found thirty-two pebbles of various sizes, which appeared to have been very recently obtained, and afforded additional evidence of our immediate proximity to land."

A tremendous storm now arose, in which the "Peacock" was so severely damaged by contact with icebergs, that it was indispensable for her to return north, which was done. It was found that "the ice had chafed the stem to within one inch and a half of the wood-ends of the planking."‡

* Ringgold's Report: "Narrative U. S. E. E.," Vol. II, p. 470.
† Hudson's Report: "Narrative U. S. E. E.," Vol. II, page 465.
‡ Hudson's Letter: "Narrative U. S. E. E.," Vol. II, page 468.

The "Vincennes" and "Porpoise" continued sailing along the coast. An ice-bound bay was explored on January 23d, and called Disappointment Bay. It was in 67° 4′ 30″ south latitude, and 147° 30′ east longitude. On the 28th there was another terrible gale, in which the ships escaped destruction from contact with icebergs by sheer good luck.

On January 30th, "we approached* within a half mile of the dark, volcanic rocks, which appeared on both sides of us, and saw the land gradually rising beyond the ice to the height of three thousand feet, and entirely covered with snow. It could be distinctly seen extending to the east and west of our position fully sixty miles. I make this bay in longitude 140° 02′ 30″ E., latitude 66° 45′ S., and now that all were convinced of its existence, I gave the land the name of the Antarctic Continent. Some of the officers pointed out the appearance of smoke, as if from a volcano, but I was of the opinion that this was nothing but the snow-drift, caused by the heavy squalls. There was too much wind at this time to tack, I therefore had recourse to luffing the vessel up in the wind, and wore her short round on her heel. At the same time we sounded, and found a hard bottom at the depth of no more than thirty fathoms. I made a rough sketch of this bay, which I have called Piner's Bay, after the signal quarter-master of that name."

At this time there was much sickness on the ship, and Wilkes sent official letters to the officers and surgeons asking for their opinion about what course should be taken. Their answers, dated January 31st, are interesting. "We have been almost surrounded† with drift-ice and ice-islands for the last twenty-three days, and coasting along the barrier of field-ice, which has rendered it impossible to penetrate further south in this vicinity; and, although gratify-

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* Wilkes: "Narrative U. S. E. E.," Vol. II, page 316.

† Purser R. R. Waldron, of the "Vincennes": "Narrative U. S. E. E.," Vol. II., page 462. This letter is important, because it proves that on January 31, 1840, the name "Antarctic Continent" had been definitely given, and also because this mention of it is probably the first time it was written officially (unless in the log).

ing it would be to land upon the Antarctic Continent, I am not aware that any advantages to be derived from it would be commensurate for the dangers it would be necessary to incur; and if the discovery of new land in these regions is important, I consider it equally so that every precaution be taken to communicate the same to others." * * * "We would state* that in our opinion, it would be as well to hold on until to-morrow at meridian, in order, should the weather then prove favorable, to attempt making the recently-discovered land at another point" * * * "I am of opinion† with due regard to the report of the medical officers, which you have submitted to our perusal, that it is very desirable to ascertain the extent of the recently-discovered land, by another attempt to the westward." * * * "I think‡ it would be advisable to remain in this vicinity at least two days longer, and if possible, get further information respecting the recently-discovered land."

"The 2d of February§ found us about sixty miles to the westward of Piner's Bay, steering to the southward, and as usual among ice-islands, with the land in sight. The land had the same lofty appearance as before. * * * Our longitude now was 137° 02′ E., latitude 66° 12′ S." * * * "On the 7th‖ we had much better weather, and continued all day running along the perpendicular icy barrier, about one hundred and fifty feet in height. Beyond it the outline of the high land could be well distinguished. * * * I place this point, which I have named Cape Carr, after the first lieutenant of the 'Vincennes,' in longitude 131° 40′ E., and latitude 64° 49′ S." "On the 10th * * * running close along the barrier, which continued of the same character, although more broken than yesterday, we saw an ap-

* First Lieutenant Overton Carr; Lieutenants A. Ludlow Case and Joseph A. Underwood; Acting Masters Edward H. deHaven, and Samuel R. Knox, of the "Vincennes": "Narrative U. S. E. E.," Vol. II, page 461.

† Lieutenant James Alden: "Narrative U. S. E. E.," Vol. II, page 462.

‡ Chaplain Jared Elliott: "Narrative U. S. E. E.," Vol. II, p. 463.

§ Wilkes: "Narrative U. S. E. E.," Vol. II, p. 320.

‖ Wilkes: "Narrative U. S. E. E.," Vol. II, p. 321.

pearance of land, although indistinctly, to the southward * * * longitude 122° 35′ E., latitude 65° 27′ S." "During the 12th* we had pleasant weather and at 2 A.M. filled away. At 8 A.M. land was reported to the southwest. * * * Land was now distinctly seen, from eighteen to twenty miles distant, bearing from south-southeast to southwest—a lofty mountain range, covered with snow, though showing many ridges and indentations. * * * We had decreased our longitude to 112° 16′ 12″ E., while our latitude was 64° 57′ S. This puts the land in about 65° 20′ S., and its trending nearly east and west."

"I gained the meridian of 105° E.† on the 12th of February, latitude 64° 54′ S.; the weather was at intervals misty, affording little opportunity for observation; many strong indications of land presented themselves. * * * As I advanced westward, the marks of the approach to land were becoming too plain to admit a doubt. The constant and increasing noise of penguins and seals, the dark and discolored aspect of the ocean, with frequent huge masses of black frozen earth identified therewith, strongly impressed me with the belief that a positive result would arise in the event of a possibility to advance a few miles further south. * * * On the afternoon of the 13th, I landed and extracted from an immense mass of black earth identified with the barrier, some hundreds of yards back from the margin, specimens of rock corresponding to those previously obtained." * * *

"13th‡ * * * In the afternoon we had the land ahead, and stood in for it with a light breeze until 6½ P.M. when I judged it to be ten or twelve miles distant. It was very distinct, and extended from west-southwest to south-southeast. We were now in longitude 106° 40′ E., and latitude 65° 57′ S. * * * 14th.§ At daylight we again made sail for the land, beating in for it until 11 A.M. when

* Wilkes: "Narrative U. S. E. E.," Vol. II, page 324.
† Ringgold's Report: "Narrative U. S. E. E.," Vol. II, pages 471,472.
‡ Wilkes: "Narrative U. S. E. E.," Vol. II., page 324.
§ Wilkes: "Narrative U. S. E. E.," Vol. II, page 325.

we found any further progress quite impossible. I then judged that it was seven or eight miles distant. The day was remarkably clear, and the land very distinct. By measurement, we made the extent of coast of the Antarctic Continent, which was then in sight, seventy-five miles, and by approximate measurement, three thousand feet high. It was entirely covered with snow. Longitude at noon, 106° 18′ 42″ E., latitude 65° 59′ 40″ S. * * * I determined to land on the largest ice-island that seemed accessible. * * * We found embedded in it, in places, boulders, stones, gravel, sand and mud or clay. The larger specimens were of red sandstone and basalt. No signs of stratification were to be seen in it, but it was in places formed of icy conglomerate (if I may use the expression) composed of large pieces of rocks, as it were frozen together; and the ice was extremely hard and flint-like. The largest boulder embedded in it was about five or six feet in diameter, but being situated under the shelf of the iceberg, we were not able to get at it. Many specimens were obtained and it was amusing to see the eagerness and desire of all hands to possess themselves of a piece of the Antarctic Continent. These pieces were in great demand during the remainder of the cruise. * * * This island had been undoubtedly partly turned over. * * * On the 17th* about 10 A.M. we discovered the barrier extending in a line ahead, and running north and south as far as the eye could reach. Appearances of land† were also seen to the southwest, and its trending seemed to be to the northward. We were thus cut off from any further progress to the westward, and obliged to retrace our steps. * * * We were now in longitude 97° 37′ E., and latitude 64° 01′ S."

The expedition now turned northward and the "Vincennes" proceeded first to Hobart Town, then to Sydney, which it reached on March 11th. Lieutenant Wilkes immediately announced the discovery of a South Polar Continent to the

* Wilkes: "Narrative U. S. E. E.," Vol. II, page 327.

† Termination Land, whose existence is still uncertain. Dr. Fricker ("The Antarctic Regions," page 221) suggests that Wilkes may have seen land by refraction.

Secretary of the Navy in the following letter, dated at Sydney, New South Wales, March 11, 1840:—

"It affords me much gratification to report that we have discovered a large body of land within the Antarctic Circle, which I have named the Antarctic Continent, and refer you to the report of our cruise and accompanying charts, inclosed herewith, for full information relative thereto."*

As far as I know, this is the first definite announcement of a mass of land, probably continental in size, in the Antarctic Region. Five or six explorers *may* have sighted the South Polar Continent prior to 1840, but none of them saw enough land to be able to assert that he had seen anything more than islands. The nearest approach to such a statement was the casual remark of Edmund Fanning about Palmer's Continent. A strong proof that there was no knowledge of an Antarctic Continent, prior to 1840, is furnished by the charts published before that date. No land is charted by Weddell, except south of South America, and on Biscoe's chart there is no land marked east of Enderby Land, up to the lands south of Cape Hoorn. Unless, therefore, some prior claim can be proved, the honor of recognizing the existence of a South Polar Continent belongs to Commodore Wilkes and to the United States Exploring Expedition.

Two days later, the first account of the discovery of a South Polar Continent ever printed, was published in *The Sydney Herald* of March 13, 1840. I have not seen the original of this, but there is a reprint of it in the *Nautical Magazine* for 1840.† The article is as follows:—

"An interesting geographical discovery has been made in the Southern Antarctic Ocean, of a Continent with a coast of about 1,700 miles from east to west, highly useful for seal and whale fishery. The most singular coincidence

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* Captain C. C. Todd, U. S. N., Hydrographer, called my attention to this letter. It was first published in Mr. G. W. Littlehales' "The navy as a motor in geographical and commercial progress;" *Bulletin of the American Geographical Society*, Vol. XXXI, 1899, pages 123–149.

† "*The Nautical Magazine and Naval Chronicle for 1840*," London, Simpkin, Marshall & Co., page 592.

is, that it was discovered by the French and Americans on the same day, January 19, 1840, at a distance of 720 miles from each other.

"Amongst the arrivals to be found in our shipping list of this day, is that of the United States ship 'Vincennes' under the command of Charles Wilkes, Esq. The 'Vincennes' has been absent from this port almost eighty days, most of which time has been spent in southern exploration, and we are happy to have it in our power to announce, on the highest authority, that the researches of the exploring expedition after a southern continent have been completely successful. The land was first seen on the morning of the 19th of January, in latitude 64 deg. 20 min. south, longitude 154 deg. 18 min. east.

"The 'Peacock' (which ship arrived in our harbor on the 22d ult., much disabled from her contact with the ice,) we learn, obtained soundings in a high southern latitude, and established beyond doubt the existence of land in that direction. But the 'Vincennes' more fortunate in escaping injury, completed the discovery, and run down the coast from 154 deg. 18 min. to 97 deg. 47 min. east longitude, about seventeen hundred miles, within a short distance of the land, often so near as to get soundings with a few fathoms of line, during which time she was constantly surrounded with ice-islands and bergs, and experiencing many heavy gales of wind, exposing her constantly to shipwreck. We also understand that she has brought several specimens of rocks and earth procured from the land, some of them weighing upwards of one hundred pounds.

"It is questionable whether this discovery can be of any essential benefit to commerce; but it cannot be otherwise than highly gratifying to Captain Wilkes and the officers engaged with him in this most interesting expedition, to have brought to a successful termination the high trust committed to them by their country, and it is hoped that so noble a commencement in the cause of science and discovery will induce the Government of the United States to follow up by other expeditions that which is now on the point of termination.

"We understand that the 'Vincennes' will sail on Sunday or Monday next, for New Zeeland (*sic*), where the 'Porpoise' and 'Flying Fish' will rejoin her, should they have been equally fortunate with their two consorts in escaping from the ice. The 'Peacock,' will follow as soon as her repairs are completed; whence they will all proceed in furtherance of the objects of the expedition.—*Sydney Herald, 13th March.*"

The cruise of Wilkes will remain among the remarkable voyages of all time. No finer achievement has been accomplished in the annals of the Arctic or of the Antarctic.* With unsuitable, improperly equipped ships, amid icebergs, gales, snow storms and fogs, Wilkes followed an unknown coast-line for over fifteen hundred miles, a distance exceeding in length the Ural Mountain Range. It is the long distance which Wilkes traversed which makes the results of his cruise so important; for he did not merely sight the coast in one or two places, but he hugged it for such a distance as to make sure that the land was continental in dimensions. The expedition noticed appearances of land on January 13th; it sighted land almost surely on January 16th, from 157° 46′ east longitude, and again more positively on January 19th, from 154° 30′ east longitude, 66° 20′ south latitude. The discovery, therefore, was made probably four days earlier than that of D'Urville. On January 30th, the size of the land was sufficiently ascertained to receive the name Antarctic Continent, and this discovery of Wilkes and that of Gerritz are the two most important discoveries yet made in the Antarctic.

It is scarcely probable, however, especially when the constant fogs and snow storms are taken into consideration, that the outline of the coast of Wilkes Land is accurate, sketched in as it was during a single reconnaissance; but that there is the shore of a continent between about 154°

* The able and impartial Sir John Murray, for instance, in "The Renewal of Antarctic Exploration," *Geographical Journal* Vol. III, 1894, pages 1-42, says at page 11: "When we remember that their ships were wholly unprotected for ice, the voyages of D'Urville and Wilkes to the Antarctic Circle south of Australia must be regarded as plucky in the extreme."

and 100° east longitude, can scarcely be doubted by anyone who reads the "Narrative." The vast number of ice islands and tabular icebergs shows that there is some extensive nucleus which retains them in an uninterrupted line on nearly the same degree of latitude, and moreover these enormous bergs are not formed, according to most explorers, in the open sea. Along this extended coast neither any open strait nor any northerly currents were observed, and the absence of both are strong proof of a continental mass of land, rather than of an archipelago of islands.

It is in accordance with tradition, however, that Wilkes should be traduced for having discovered something. Marco Polo's account of the *Ovis Poli* was disbelieved for six hundred years. Columbus was put in chains. Amerigo Vespucci, who, like Wilkes, first recognized the existence of a continent, has not, even yet, had his character restored to him. Baffin's Bay took many shapes during two centuries and was just disappearing altogether when Sir John Ross saved it. Abel Tasman was told that he had not accomplished anything and that better men would be sent. Paul B. du Chaillu, the hunter of the gorilla and the discoverer of the pigmies, was advised by his publishers "to stick to it." Henry M. Stanley learnt that he had been rescued by Dr. Livingstone, who was "in clover," *et cetera*. It is not to be wondered at, therefore, that Wilkes should be disbelieved; but the fact that he has been so much attacked only proves that he did discover something of which the world was ignorant at the time.*

* Some of the officers of the United States Expedition—William M. Walker, Lieut.; Robert E. Johnson, Lieut.; James Alden, Lieut.; John B. Dale, Lieut.; Edwin J. DeHaven, Lieut.; A. S. Baldwin, Lieut.; George T. Sinclair, Lieut.; William Reynolds, Lieut.; Simon F. Blunt, Lieut.; William May, Lieut.; Joseph P. Sanford, Lieut.; George Colvocoressis, Lieut.; James Blair, Passed Midshipman—felt aggrieved about some of the statements publisited by Lieutenant Wilkes in his "Narrative." In consequence they prepared a paper: "Memorial of Officers of the Exploring Expedition to the Congress of the United States;" Washington, January, 1847, page 23. All the complaints made by these officers are purely *personal* ones, about matters or charges which they considered reflected on them personally. The only mention at all of the Antarctic cruise is the following (page 12): "'Vol. 2, page 359—Lieutenant Pinckney was enabled to come again on deck, who had scarcely

Impartial geographers in due time recognized the importance of Wilkes' discovery, and in recognition of his work affixed the name of Wilkes Land to the portion of the Antarctic Continent along which he coasted. I do not know who suggested the name of Wilkes Land, nor on what map or atlas it first appeared, but it is found as far back as 1866, in "Stiehler's Atlas," Justus Perthes, Gotha. It is found also in Bartholomew's "The Library Reference Atlas," 1890; in the "Library Atlas of Modern Geography," D. Appleton, New York, 1892; in Justus Perthes' "Taschen Atlas," Gotha, 1893; in Sir John Murray's map, "Geographical Journal, Vol. III, 1894; in Alex. Keith Johnston's "The Royal Atlas," 1894; in "The Century Atlas," 1897; in "The Times Atlas," London, 1895, 1896, 1897, *et cetera*. Hachette's "Atlas de Poche," Paris, 1894, prints "T. de Wilkes," and it is particularly instructive to find the countrymen of Dumont D'Urville using the term. Some geographers still use the term "Antarctic Continent." Colton's "General Atlas," New York, 1888, for instance, does so, and also the Hydrographic Office in Washington. Some map makers, however, use neither name. In Black's "General Atlas of the World," Edinburgh, 1876, there is the complete outline of Wilkes Land, but no American name whatever, and only Adélie, Clarie and Sabrina Land. In the "Encyclopædia Britannica," ninth edition, article "Polar Regions," is a map with the names given by Wilkes and D'Urville, as well as Sabrina Land, but with neither "Antarctic Continent," nor "Wilkes Land."

There is no doubt, however, I think, that in due time, in accordance with the excellent precedent of commemorating the names of explorers, the name already in general use among geographers will prevail, and that on future charts, instead of "Antarctic Continent" there will be placed "Wilkes Land."

[*To be continued.*]

been able to quit his berth since leaving Maquarie Island, from sickness.'" The following half page explains that this sentence is incorrect, and that the commander of the "Flying Fish" was on duty, with the exception of one or two days, during the whole of his cruise in the Antarctic.

ROTARY TRANSFORMERS:

THEIR HISTORY, THEORY AND CHARACTERISTICS.

By George W. Colles, A.B., M.E.

(*Continued from p. 368.*)

THE INDUCTORIUM.

We return to this class from the point where we left it, on page 222*; but better prepared to consider its capabilities, and from a different standpoint; and we commence by redefining the inductorium—as we shall at present consider it—as a self-contained induction coil or series of coils, one of whose sides is connected to a commutator, adapting it to mediate between alternating or polyphase and continuous currents. By "self-contained" is meant that it is not acted on by external magnetic fields; and it is hence, in general, stationary.

Some pages back (page 362†) the suggestion was referred to that polyphase generators and their corresponding transformers might be made with a very large number of phases, as many, in fact, as the secondary of the transformer has commutator segments. Now, supposing this to be the case, if we provide means for continuing the synchronous rotation of the commutator, there is no longer occasion for an armature to assist the commutation of the current, because each commutator bar, as it comes under the brushes, will assume its maximum potential, which is that of the *D C* circuit, which latter, therefore, is supplied with a constant (or sensibly constant) pressure.

Now, as it is not convenient to carry thirty or forty line-wires from the generating station, we must, to accomplish this transformation, obtain some means of first transforming the polyphase current of two or three phases only into the requisite large number of phases. Now, this is done without the slightest difficulty by means of the original

*March number of this *Journal*.

†May number of this *Journal*.

ring transformer shown in Plate XIV, in the manner already mentioned on page 263.* Dividing the secondary coils into the requisite number of segments and connecting them through slip-rings to the respective segments of the commutator above mentioned, we at once have our inductorium.

This is the fundamental principle upon which are constructed most of the recent machines of this type; and, with a slight addition, most of the frequency changers as well. As we see, our new apparatus is nothing more than a metamorphosed two-coil rotary armature, minus the fields.

This simple form is shown in Plate XXI, *Fig. 1*.[75] Here *R* is the induction ring, double-wound with an open-coil two-phase primary, as in Plate XIV,† *Fig. 1*, and a Gramme-wound secondary, connected up to the stationary commutator *C*, upon which brushes *x y* are synchronously revolved by the auxiliary magnet *A*, delivering continuous current to the slip-ring brushes *p q*. (*Fig. 2* is an alternative form with double auxiliary magnet.)

The old ring form of transformer, when used in this manner, is, however, as we already saw on page 219,‡ when treating of the *D C* inductorium, and again on page 264,§ when speaking of the polyphase transformer, inefficient and unsatisfactory on account of its open magnetic circuit, or free poles at opposite sides of the ring. Now, by juxtaposing another ring with free poles of opposite kind, we complete the magnetic circuit (*Fig. 3*). Or we may place within the ring an iron drum, which effects the same purpose (*Fig. 4*).

In these cases both cores may be wound with primary and secondary circuit and the proper one commuted at the brushes. Or on the other hand we may wind the primary on the exterior ring, and the secondary drum-fashion on the center-piece (*Fig. 5*), or *vice versa* (*Figs. 6* and *7*). In all these cases both cores are fixed, and only the brushes *x y* rotated on their spindle by the bar magnet *A*.

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*April number of this *Journal*.

[75] Zipernowski and Deri's patent, No. 433,758, of August 5, 1890.

†April number of this *Journal*.

‡March number of this *Journal*.

§April number of this *Journal*.

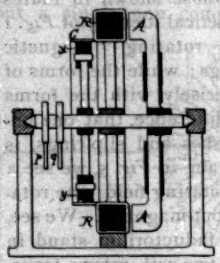

Fig. 1.

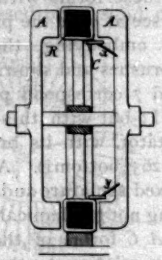

Fig. 2.

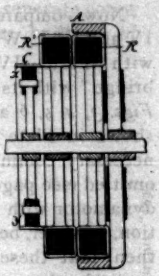

Fig. 3.

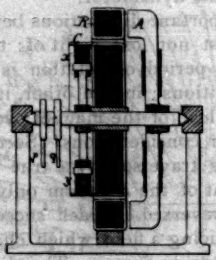

Fig. 4.

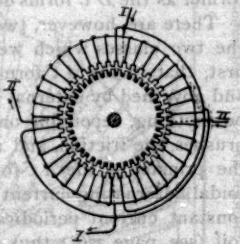

Fig. 5.

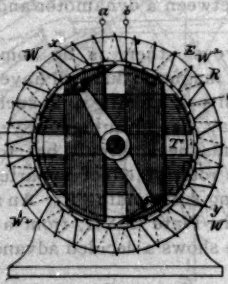

Fig. 6.

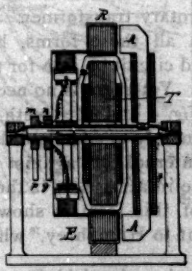

Fig. 7.

PLATE XXI.—Various forms of inductorium, as given by Zipernowski & Déri. 1890.

Now compare these forms with those shown in Plates IV and VI.* We see at once the practical identity of *Fig. 1* with Plate IV, embodying the rotating "magnetic bridge" with its brushes and slip-rings; while the forms of *Figs. 3, 4, 5, 6* and *7* correspond precisely with the forms shown in Plate VI; but with this difference, that one unnecessary commutator, with its brushes and slip-rings, is omitted (see page 263, bottom†). Again, in *Fig. 5*, we see a dynamotor with fixed armature and rotating field; the rotation, however, being not mechanical, but magnetic. We see, then, that these *A C* forms of the inductorium stand in precisely the same relation to the two-coil rotary transformer as the *D C* forms do to the dynamotor.

There are, however, two important distinctions between the two classes which we must not lose sight of; to wit, first, that in the *A C* form the period of rotation is fixed and governed by external conditions; in the other, it may be anything, depending on the lead of the magnet over the brushes, the friction, and minor considerations. Secondly, the primary of the *A C* form is traversed by a true (sinusoidal) alternating current; that of the *D C* form only by a constant current periodically reversed in each successive coil (see page 276‡), thus producing a field which changes intermittently by a series of steps or jumps. The distinction is as essential as that between a dynamotor and a two-coil rotary transformer.

In all these forms, however, there is no completely closed circuit of iron for the magnetic flux; all have an air-gap. Yet there is no necessity of an air-gap in such forms as *Fig. 5*, and the teeth may be advantageously joined, not merely to complete the magnetic circuit, but to brace the internal core against the rotative effect imparted to it by the rotating field in the ring surrounding it. An apparatus of this form is shown in Plate XXII, from a recent patent to Humphrey,[76] which shows a decided advance over

*March number of this *Journal*.
†April number of this *Journal*.
‡April number of this *Journal*.
[76] No. 628,807, of July 11, 1899.

previous forms. We no longer have two separate cores, but a single one composed of a solid core built up of

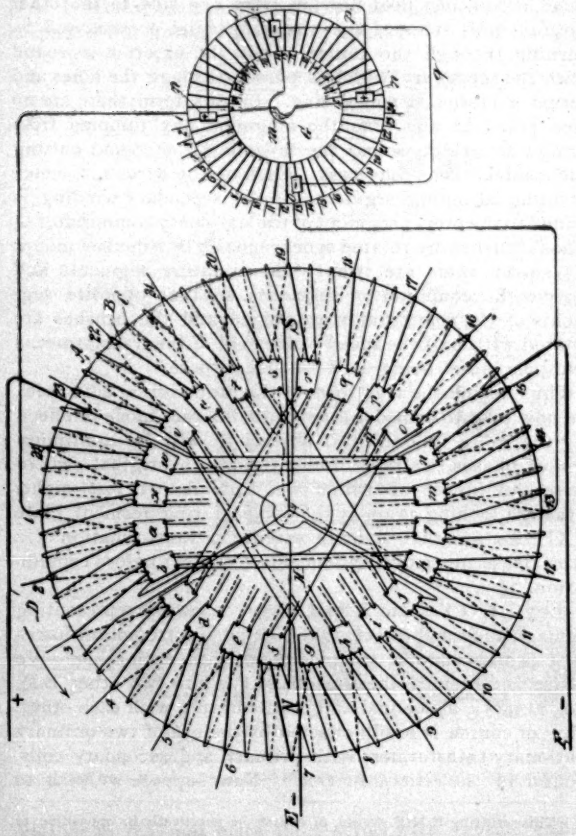

PLATE XXII.—Humphrey's inductorium, with closed magnetic circuit. 1899.

laminated disks and punched with a series of holes *a*, *b*, *c*, etc., midway between the centre and the periphery. As

shown, the primary is wound for a three-phase current, both exterior and interior being wound, as shown, so as to produce a rotating field flowing from one side to the other around both sides of the circumferential portion, and returning through the centre. Only the exterior is wound with the secondary, which is passed through the holes and forms a closed Gramme ring. In this form there are no free poles at any time, the magnetic flux jumping from bridge to bridge across the holes *a*, *b*, *c*, etc., and cutting the conductors as they pass. Each of the wires *1*, *2*, *3*, etc., dividing adjoining segments of the secondary winding, is joined to the proper segment of the stationary commutator *G*, whose brushes are rotated synchronously by a donkey-motor. As shown, there are twenty-four armature segments and forty-eight commutator segments, so that opposite segments of the commutator are joined, and the brushes are rotated with half the speed of the field of the transformer, a four-pole motor being used for this purpose.

Thus far has the ring form of the inductorium advanced; we now pass to consider a new and different mode of effecting the same fundamental object—to wit, the multiplication of phases to a large number from an original two or three—an object of which we had almost lost sight; although looking again at the compact ring form of Plate XXII, we see that it is in essence a transformation of a three-phase into a twenty-four phase current before commutation.

Let *O X*, *O Y* (Plate XXIII, *Fig. 1*) be vectors representing in magnitude and direction two equal electromotive forces in a primary circuit in quadrature with each other. We desire to transform these two E.M.F.'s into two other E.M.F.'s, *O* x, *O y*, also equal and in quadrature with each other. This, of course, is easily effected by the use of two ordinary stationary transformers with primary and secondary coils, wound in the ratio *O x*: *O X*.[77] Now suppose we wish to

[77] This resulting E.M.F. would, of course, be practically in opposition to the original E.M.F.'s *O X*, *O Y*, but they preserve the same relative angle with regard to each other, and their representation in the same axial directions do not affect the demonstration.

produce a new E.M.F. of the same strength Ox, but differing from it in phase by 45°. Let this be represented by Om. It is clear then that if we take a secondary winding On in the first transformer of a length equal to $On = Ox \div \sqrt{2}$

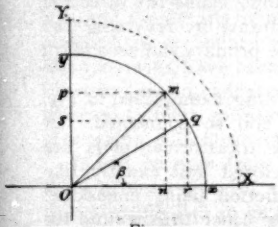

Fig. 1.

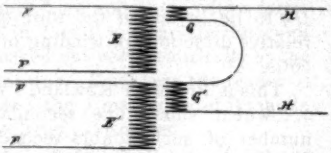

Fig. 2.

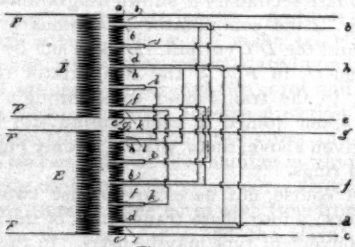

Fig. 3.

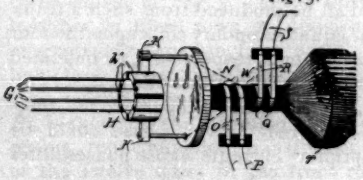

Fig. 4.

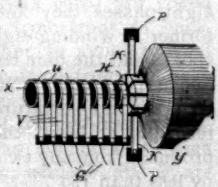

Fig. 5.

PLATE XXIII.—Rowland's method of transformation for polyphase currents. 1899.

relative to OX, and place it in series with another equal length of secondary winding Op in the second transformer, we shall produce the desired E.M.F. In the same way a

secondary E.M.F. of any desired magnitude and direction Oq, making an angle β with Ox, may be produced by simply joining in series two secondary windings of lengths $Or = Oq \cos \beta$ and $Os = Oq \sin \beta$ wound upon the respective transformers. We may, of course, cause the direction Oq to lie in any of the four quadrants by reversing the relative directions of winding of the primary and secondary coils.

This is Professor Rowland's winding, exemplified in *Fig. 2*,[78] which shows one secondary coil so connected. A number of such double secondary transformer coils are wound, and connected up in a closed coil exactly like a Gramme ring, each point of junction being connected to a commutator segment. A transformer thus wound for an eight-phase secondary is shown diagrammatically in *Fig. 3*. In *Fig. 4* the commutator is stationary, the brushes rotating, and the $D\,C$ current is taken off by the slip-ring connections O; in *Fig. 5*, the commutator rotates and is connected to the transformer coils through a number of slip-rings u, one joined to each commutator segment. In the case given above, there would be only eight such segments and rings.

It is, of course, not necessary to use two independent transformers; a four-phase transformer of the spoked wheel or other convenient type may be used. In the case of only eight phases, they could all be produced from such a transformer by winding eight equal secondary coils upon the four spokes and the four rim-segments, respectively, as indicated above (page 266*). Nor is it necessary that the primary currents be in quadrature, in the general theorem; for theoretically, at least, the required derived phase could be produced from any two primary currents whose phases differ by less than 180°.

It will be seen that the Scott method of transforming two-phase into three-phase currents (page 267†) is a special case of the foregoing.

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[78] *Figs. 2, 3, 4 and 5* are from the specification of his patent No. 628,358, of July 4, 1899.

*April number of this *Journal*.

†April number of this *Journal*.

An apparatus operating on the same general principle, but showing a large advance in practical construction, is that shown in a recent patent to Messrs. Hutin and Leblanc,[79] of Paris, and depicted in Plates XXIV and XXV. These ingenious inventors have taken a broader view of the problem, and the details for a three-phase apparatus with a forty-eight-phase secondary, and in fact the complete theory of the apparatus, have been worked out very beautifully by the inventors in sinusoidal equations. For these the reader is referred to their specification; the apparatus and its mode of working will, however, be briefly described.

It will be seen from *Fig. 1*, in which H_1, H_2, H_3 are the three primary circuits, and *1*, *2*, *3*, etc., the secondaries, that the principle lies in extending each secondary circuit successively across each of the three primary mains in a transformer winding of appropriate length. As there are forty-eight secondary circuits, this would make 144 transformer cores; but as one-half of these circuits are in opposition to the other half, we need but seventy-two cores, half the forty-eight circuits being wound in reverse direction. To conveniently dispose this great number of cores, the inventors arrange them on two sides of the chamber in which they are stored, each side containing thirty-six cores arranged in two stories, with six tiers of three cores each from front to back, as exhibited in the plan, *Fig. 2*, and the elevation of the cores shown in *Fig. 3*. These thirty-six cores are yoked together in three rows or divisions from front to back, magnetically separate from each other to avoid mutual induction. The three rows of cores from front to back each belong to a separate primary circuit, one of which, H_1, is shown in the elevation of one of the two frames composing the completed transformer, as connected to each of the twelve cores in the front row, while H_2 and H_3 are respectively connected to each core in one of the other two rows. Now, referring again to *Fig. 1* and the main theory, the disposition of the cores and windings is such that each secondary E.M.F., *1*, *2*, *3*, etc., will differ in phase by an angle

[79] No. 644,553, of February 27, 1900.

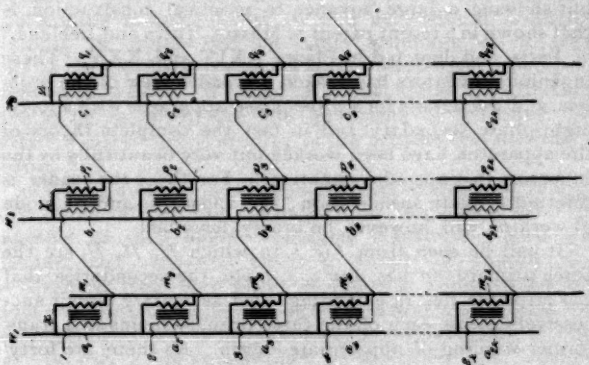


Fig. 1.

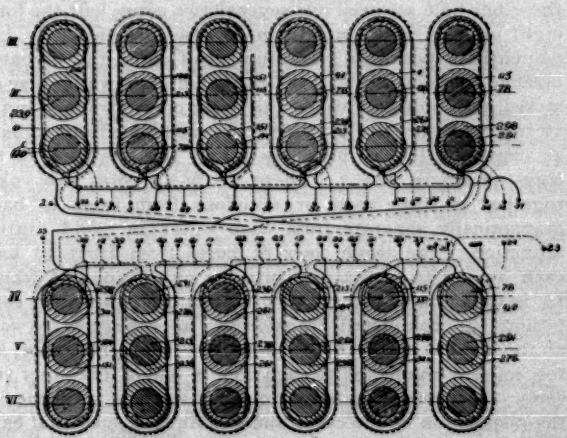


Fig. 2.

PLATE XXIV.—Inductorium of Hutin & LeBlanc. 1900.

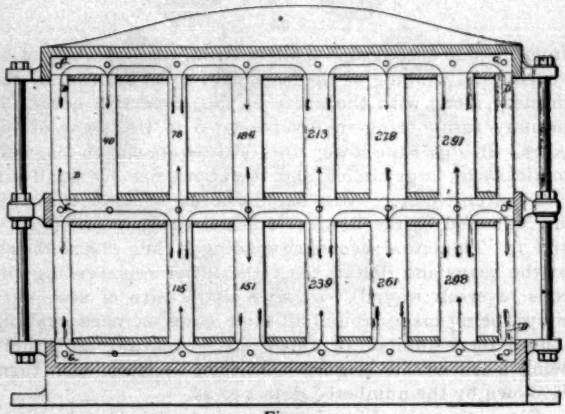


Fig. 3.

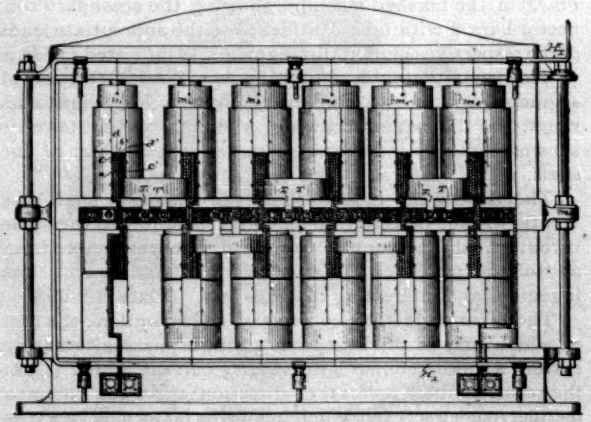


Fig. 4.

PLATE XXV.—Inductorium of Hutin & LeBlanc. 1900.

$$\frac{2\pi}{48}$$

from the one preceding. This is arranged, however, not by varying the winding of the secondary coils, but that of the primary, along with the areas of the respective cores, the primary turns being in inverse ratio to the areas of the cores. In *Fig. 2* the lower rows of cores are shown diagrammatically by large circles, and the upper row by small circles concentric therewith; but the actual areas of the cores are indicated by the figures attached to each core (*Figs. 2* and *3*). The actual secondary winding is then just as shown by the heavy and dotted lines (the latter representing the coils reversely wound), *Fig. 2;* a single turn of secondary circuit being taken around all three cores at once (making thus a total number of turns $144 \div 3 = 48$), and there being a commutator segment attached between each turn, as shown by the numbered dots *1* to *48*.

Fig. 4 is a general front elevation of one side (the *upper Fig. 2*) of the finished machine, showing the secondary connector bars *T* with tabs *T'* attached to the appropriate leads of the respective commutator segments, as indicated in *Fig. 2*.

The commutator is a rotating one, having forty-eight segments connected to the several cores by forty-eight slip-rings; in the patent drawing, a double commutator is shown, driven by a three-phase motor at each end of the shaft.

The last of the inductorium type which we shall here mention is one described in an earlier patent [80] to the same inventors, which operates upon a different principle from any of the machines hitherto described, and one no less ingenious and interesting than the last. (Plate XXVI.)

There are, in fact, two objects of the invention; the first of which aims to produce from a single-phase alternating current a unidirectional but *pulsating* current, which is not the result of mere reversal of direction, as in the common rectifier (page 211*), but which follows as far as may be a true

[80] No. 572,510, of December 1, 1896.

* March number of this *Journal*.

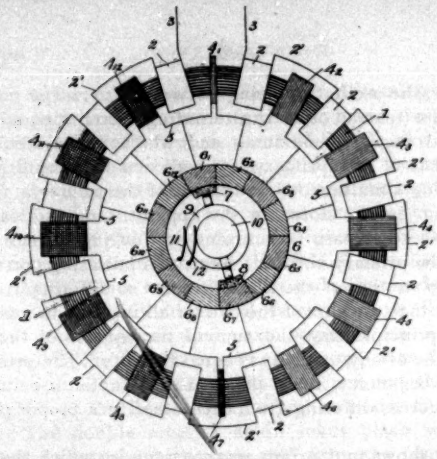


Fig. 1.

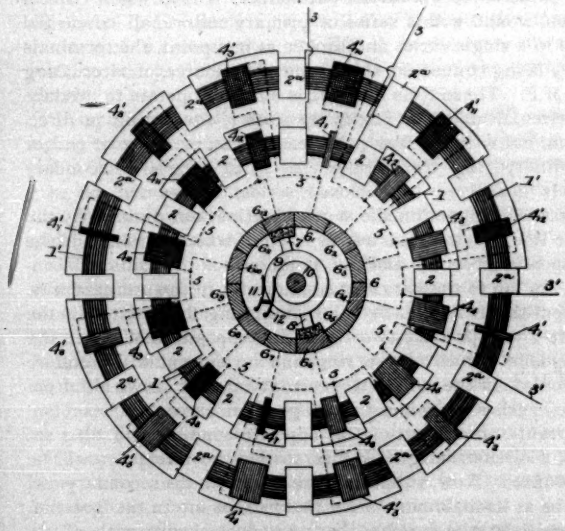


Fig. 2.

PLATE XXVI.—Hutin & LeBlanc's ring inductorium. 1896.
Fig. 1, for alternating currents; *Fig. 2*. for two-phase (four-phase) currents.

sine law, the oscillation being between zero and a positive maximum (instead of, as in alternating currents, equal positive and negative maxima), and which has a frequency twice that of the primary; its zero and maximum points thus being simultaneous with those of the primary. There is thus no energy stored in the apparatus, magnetically or otherwise, to sustain the current flow during the zero periods of the primary current. Next, this pulsating current is added to another of the same sort, but so differing from it in phase that the sum of the two for all instants is constant, on the principle that the sum of the squares of the sine and cosine of any quantity is equal to unity. The principle of such constancy holds also, as is known, for any number of such forces differing from each other by a proper phase-angle.

Fig. 1 shows in diagram an apparatus by which the first of these objects is carried into effect. *1* is a ring or core of iron, wound with a series of primary coils *2*, all connected up in a single series and broken at one point, the terminals *3, 3* being connected to any suitable source of alternating E.M.F. These coils *2* will, it is obvious, operate to produce a circular magnetic flux in the core *1*, alternating in direction, but without free poles, exactly as in a choke coil or ordinary ring transformer. 4_1, 4_2, 4_3, etc., are secondary coils connected in a closed series, not wound, as in a Gramme ring, all in the same direction, but divided by the the line 6_1 6_7 into two halves, each of which is wound in the opposite direction, and the junctions of the coils all connected up to the bars of a commutator in the ordinary way. From this it is seen that the alternating flux set up in the core *1* will produce two equal and opposite E.M.F.'s in the opposite halves of the ring, and no current will therefore circulate in the ring, but a current may be drawn off from the brushes *7, 8* when in the position shown. These two currents, on account of the opposite winding, will also set up a circular magnetic flux, so that no free poles will be produced. Now, supposing the E.M.F. in the secondary coil to be at its maximum when the brushes are in the position shown, let the brushes be rotated clockwise with a fre-

quency equal to that of the current. Assuming for the present each coil 4 to be of equal size, when the brushes have reached the bars 6_2, 6_8, the E.M.F. will now be only that due to the four coils 4_2, 4_3, 4_4, 4_5, because the two coils 4_1 and 4_2 will be mutually neutralized, and the same is true of the coils 4_6, 4_7. In this way we reach, when the brushes have arrived at the bars 6_4 6_{10}, a condition in which all the coils oppose each other, and the E.M.F. is consequently zero. At the same instant the flux and also the developed E.M.F. in each individual coil is zero. Now when the brushes have reached the next segment, an E.M.F. is developed in the secondary coils in the opposite direction, but as the brushes have reversed their position the resulting E.M.F. at the slip-rings *11*, *12* will be in the same direction. The double reversal again takes place when the brushes have passed through 180° from the former zero point. Thus the current in the secondary circuit will be zero twice in a revolution, and will also be a positive maximum twice in a revolution; its E.M.F. is therefore always positive and has a frequency double that of the primary circuit.

If equal-sized coils are employed, the curve will take a zigzag shape composed of straight lines, if the number of commutator segments is supposed infinite. But we may give the coils such dimensions, as indicated in the drawing, that the curve shall be truly sinusoidal, or we may vary the width of the commutator bars to the same end.

When this coil is used alone, a choke coil of special construction is used by the inventors to diminish the pulsations in the secondary circuit. By adding another coil (*Fig. 2*), whose impressed E.M.F. is in quadrature with the first, connecting each coil of one in series with a coil making an angle of 90° with it in the other, the two added E.M.F.'s produce a constant E.M.F. equal to the maximum developed in each coil taken singly. Only a single commutator is necessary for this arrangement. With a three-phase primary, three rings are required connected in like manner, but dephased from each other by an angle of 120°.

This machine, as shown in diagram, has a stationary

commutator with rotating brushes; but, in practice, the inventors prefer to couple it by numerous slip-rings to a rotating commutator, provided with stationary brushes. Such a commutator is shown having n slip-rings and $3n$ segments, each ring being connected at three points 120° apart; the synchronous motor driving it has therefore $3n$ pairs of poles. The brushes may be thus set at 60° apart if desired.

It will be observed that this machine operates on a fundamentally different principle from those previously described, as no rotating magnetic fields nor polyphase currents are produced in either ring, nor are the number of phases increased.

All the types of machine above described are completely reversible, except the single-ring type of that last described.

The theory of these machines is very elegant, and their theoretical advantage over other types, such as the rotary transformer, undoubted. Practically, stationary transformers,—always necessary with the latter where high pressure is used—are replaced by the stationary part of the machines themselves,—which, so far as can be seen, *ought* to be of substantially the same efficiency; while, again, the rotary transformer is replaced by a mere rotating commutator—with numerous slip-rings, it is true, but still diminutive with respect to the total power transformed—using no power but that absorbed by a small donkey-motor.

The ultimate question is, however, one of practice. What is its practical efficiency, and what are its defects? —these are the questions put by the users. The machines are of so recent a date (in their improved form at least) that very little data is yet at hand, so that little can be said on this point. So far, the only objection urged against it is sparking at the commutator; but this is probably more prejudice than fact. It is claimed by its abettors that the sparking can be regulated in precisely the same way as a continuous-current dynamo—by giving the brushes the necessary lag or lead; and this does not seem unlikely. It seems rather that the notorious defects of the old continuous-current inductorium, which was never guilty of an

alternating current in the true sense, have been fathered upon the new and different type. So far as facts go, it is generally understood that a number of machines of the Hutin-Leblanc type are working on the continent of Europe, and giving no trouble in this direction. We may add further that, according to Professor Thompson,[81] Mr. Kolben, of Prag, reports having used one of these machines continuously for eighteen months, and with "excellent results." The machine transforms three-phase to continuous currents, which are used to charge accumulators. "There is," he continues, "no sign of sparking at the brushes (which are fixed) even with a varying voltage. Its efficiency is at least 95 per cent., including allowance for losses in the stationary transformers, and its cost and maintenance much smaller than that of a rotatory converter." (Why stationary transformers were used does not appear.)

We must, of course, await further information before passing final judgment on these machines, but in the meanwhile it seems safe to predict that they will in the near future prove a formidable rival to the one-coil rotary, if they do not ultimately displace it altogether.

[*To be concluded.*]

Mining and Metallurgical Section.

Stated Meeting, held Wednesday, January 9, 1901.

UTILIZATION OF THE WASTES FROM THE USE OF WHITE METALS.

By Joseph Richards, Member of the Institute.
(Being the Address of the Retiring President.)

It is now more than forty years since I first seriously considered that in the use of what were then called "waste products" from metallurgical operations there was a field almost untouched, and in treating the subject of my paper this evening I shall confine myself chiefly to an account of my own work in this line.

[81] *Jour. I. E. E.*, V. 27, p. 737, Nov. 24, 1898.

The white metals to which I refer are silver, tin, zinc, antimony, bismuth, lead, mercury and their various alloys, and my paper will treat of the methods which I have found most serviceable in utilizing the waste products resulting from the use of these metals either singly or as alloys. In reference to the utilization of silver wastes, the subject is so well known that I will refer to this only in connection with the recovery of silver from plated ware in another part of my paper.

First in order, I will relate my experiences in connection with

THE UTILIZATION OF TIN CLIPPINGS AND GALVANIZED-IRON SCRAP.

When first I turned my attention to the subject, I found that large quantities of tin scrap and galvanized iron were every day carted to the dumps.

I found that the average coating on scrap tin, as tin on tin plate, was 3 per cent.; that the iron if properly cleaned could be used in the nobbling furnace and in the puddling furnace; that the use of galvanized iron was a necessary part of the process; and it looked so encouraging that we decided to build a plant to work it on a commercial scale.

I procured a half dozen of the large lager beer casks used for storage, and which are about 6 feet in diameter and 6 feet deep. After removing the heads, they were placed in the ground in a semicircle and a crane was rigged up that commanded all the tanks.

In the first tank was charged hydrochloric acid; in the second, water; in the third, water with a little lime; in the fourth, water; and in the fifth, a solution of copper sulphate.

The plan of work was to fill a large wooden cage that would hold loosely about 200 pounds of the clippings. This was swung on the crane and placed in No. 1 tank. In ten minutes' time the cage was raised and the clippings examined to see if the tin was dissolved. If so, the cage was then lifted out of the acid tank and another cage filled with clippings took its place. The cleaned scrap was

washed in the water tank No. 2, lifted up and down to well wash it, and then immersed in the lime tank, No. 3. This neutralized all the residual acid that was left in the pores of the iron. The untinned and limed scrap was then moved to water tank No. 4 for a final washing, then plunged for a moment, just enough to submerge it, in the copper sulphate solution, then immediately removed. The object of this treatment was to form an exceedingly thin film on the iron to prevent the rusting of the clean iron, which is so sensitive when exposed to the air that it will almost instantly cover itself with rust. The cleaned scrap was compressed in a drop press into balls, and in this form was shipped to the iron works and worked into blooms for sheets, commanding a price of from $10 to $12 per ton.

After the process had been continued for some time, all the acid in No. 1 tank would become neutralized and we would have a solution of chloride of tin.

The process of tin cleaning stopped here for a while. We then took a cage of galvanized iron scraps, filling the cage loosely. When the zinc came in contact with the tin solution, the metallic zinc took the place of the tin, forming zinc chloride, and all the tin was precipitated as metallic tin, in a finely divided state. We worked this plant successfully for some time, recovering, when melted into ingots, about 600 pounds of tin fron 10 tons of scrap. The recovered iron commanded $10 per ton and the zinc chloride $20 per barrel, for disinfectant purposes and for treating wood to make it fireproof.

We finally closed the works because of the objectionable vapors that annoyed our neighbors, with the intention of rebuilding on the swamps near Chester, but other things prevented us doing so. I yet think it is the best and most profitable means of utilizing this scrap, especially if electricity is used for the disposition of the tin.

WASTES FROM THE GALVANIZING PROCESS.

While working up the tin scrap, I turned attention also to the wastes from the galvanizing process. In order that you may understand the problems involved, I will give a brief description of the process as then and now practised.

The trade term "galvanizing" relates to the coating of iron with zinc. In order to do this the iron article to be coated must first be surface-cleaned from all dirt and other impurities, so as to present a perfectly clean metallic surface. If any dirt, scale or oxide remains on the surface, the zinc will not adhere to that part, and imperfect work will be the result. This cleaning is done by immersing the article in a bath of sulphuric acid and water, well washing in water, plunging in hydrochloric acid for a short time and drying. The article is then put into the bath of molten zinc. If sheets, or similar articles that will not hold much water, are being coated, the drying may be dispensed with to advantage. The galvanizing tank, or bath, as it is called, is of necessary size for the articles to be submerged, varying from ½ ton to 30 tons capacity.

This tank is usually oblong in shape and is divided on its surface, by a longitudinal partition, into two parts. On one side of the division a suitable flux is placed which will dissolve the oxide of zinc on the surface or prevent its formation. The flux used is ammonium chloride, or, in trade parlance, sal ammoniac.

The other side of the bath is kept clean by continually skimming off the oxide of zinc as fast as it forms. In this skimming of the pot considerable shot metal is unavoidably removed with the oxide.

The side with the sal ammoniac soon becomes covered with a thick black scum which consists of the dissolved oxide, which has partly decomposed the ammonium chloride and formed a double chloride of zinc and ammonium.

The sal ammoniac must be fed continually to the top of the pot so as to keep the surface of the molten zinc clean and free from oxide, or else the oxide will adhere to the iron surface and affect injuriously the finished product by leaving spots uncoated with zinc.

By the continued addition of sal ammoniac the scum accumulates on the top of the pot and soon gets too thick for the workman to push his plates or other articles through, so a portion is removed from time to time. This yields on one side a waste called sal-ammoniac skimmings, and on the other side, zinc oxide or zinc skimmings.

Yet another by-product is made that is called zinc-slab dross. This is formed by the continued washing away of a portion of the iron that is being galvanized; for zinc in a molten state will alloy with iron, so that as soon as the iron becomes as hot as the bath its surface begins to dissolve in the zinc. If from accident or design a piece of iron is left in the bath after this dissolving process commences, it will in time be entirely dissolved. We often find bolts, nails, castings, etc., from the bottom of the bath that are nearly all, as it were, eaten away or dissolved in the zinc.

This addition of iron to the bath forms an alloy of iron and zinc that is of greater specific gravity than the zinc itself and which falls to the bottom of the bath. If the bath is run hot it collects very fast, but under ordinary circumstances a bath of the usual size for pipes or sheets will make a ton of this dross in a week.

In order to have depth enough to do the work properly, the dross must be removed. This is usually done every Saturday afternoon. A large spoon is used, perforated with holes to allow the zinc to drain out, and the semi-fluid dross is pasted into moulds, smoothed off with a shovel, and is then the slab dross of commerce.

Thus it appears that we have three by-products: Sal-ammoniac skimmings from one side, zinc oxide or zinc skimmings from the other, and slab dross from the bottom of the bath.

Sal-ammoniac Skimmings.—At the time named, 1871, there was no use for the sal-ammoniac skimmings, and at all the works where I inquired they were throwing it away.

I commenced experiments to separate this waste into three parts, for I knew that the sal ammoniac, if recovered, could be used again, also the metallic zinc, and I thought I could find a use for the zinc oxide if it could be freed from its impurities. Simple as this problem appears, it was not solved without much labor. I found by leaching these skimmings with hot water and steam that I got all the zinc chloride and ammonium chloride in solution. This I evaporated down and recrystallized for use again on the bath. The residue, after washing with water and drying, I

found to contain zinc oxide with some little dirt and shots of metallic zinc. I placed this in a tumbler, or octagon-shaped barrel, with the joints not very tight. After revolving for some time, all the oxide lumps were ground to powder and the metallic particles were nice and clean, ready for melting on the top of a pot of molten zinc. The oxide, in the shape it was in, was worth $30 per ton to the makers of zinc white paint.

I had to induce the paint men to buy this new product, but they were surprised, on using it, at its value to them, and willingly gave me the above price.

The average yield was:

	Per Cent.
Zinc	20
Ammonium and zinc chloride	30
Zinc oxide	35
Iron scale and dirt	15

I visited the galvanizing iron works, bought up what waste I could and contracted for future deliveries for one, two or three years in advance. At the McCollough Iron Company's works in this city we dug up a large part of their yard, where the stuff had been thrown for filling, and it realized about $300 a car load. Also in Pittsburgh, I found a dump where it had been thrown for years, and though it was badly mixed with dirt and ashes, I gave them $50 a car load for all that they could recover. At Winches' old iron mills in this city many of the tanks had been cut up and the "salamanders" of dross had been used for filling up the Delaware River wharves. All that was left I purchased. The largest lump I ever treated was one that yielded, when melted and refined, 25,000 pounds of good spelter.

The oxide found ready sale to the Bergen Point Zinc Company, who took all I would send them for years, but soon my men were approached and double wages bought my secrets. To-day the process is generally known in the trade and is practised by the largest zinc oxide makers in this country and in Europe.

Zinc Oxide Skimmings.—This, as previously mentioned, consists of zinc oxide and shot metal. I had no particular

trouble with this waste. All that was needed was to place it in the tumbler or barrel before described and then melt the resulting shot metal in our furnace, pouring into suitable ingots for use again.

I found at Trenton one accumulation of several hundred tons of mixed skimmings that they had tried to roast for zinc white, but the sal ammoniac and the zinc chloride rotted thousands of dollars' worth of flannel bags and the operation had to be abandoned. By my process it was all used up profitably.

The galvanizers now keep their skimmings separate, are very careful of them, and last year the price for this product was advanced from $15 to $40 per ton, according to its quality.

Zinc Dross.—We now come to the third and most important residue, zinc dross, or zinc contaminated with iron. Here, I would preface my remarks by saying that, as a pioneer in this industry, I had to gradually feel my way. All the work done was original with myself. I had no outside help from books, and from that day to this my work has been one long experiment. I feel that in the limits of this paper I can only just touch on the successful part of my work, without recording the many failures.

At the time I began working in this line, the greater part of the slab zinc dross was sent to England. The only known way of using it to advantage was to distil it in retorts just as zinc is originally made from the ore.

My first experiments were directly in this line. I built a retort furnace and made very good commercial zinc, but the process was very costly. I immediately began devising ways and means for recovering the zinc without so much cost and so expensive a plant. I found that the distilling cost from $30 to $35 per ton.

Many were the experiments I conducted; my idea being that if the dross was melted in a suitable furnace I ought to be able to separate the iron from the zinc when in a molten state.

First, I took a crucible, and when the metal was melted I injected cold air to oxidize the iron, with the result of

oxidizing the zinc; then hot air, but with still quicker oxidizing of the zinc. Steam was a slight improvement; superheated steam was better; salts of the alkalies all acted on the zinc, but sulphur gave good results. I continued these experiments on a large scale, using larger furnaces, so that I could treat several thousand pounds at a time.

Once I had a very interesting experience. Thinking that the zinc and iron alloy should be as hot as possible so that the sulphur would more readily attack the iron, the temperature of the metal was gradually raised, but too high, for as soon as the sulphur was immersed it fired the pot and immediately the center rose in the air to a height of several feet and lumps of molten zinc, all on fire, flew in a perfect shower. It was a little volcano threatening death and destruction to all around. My men ran away; I seized the fire hose and by sprinkling only on top succeeding in quenching the fire. It will suffice to add that the experiment was never repeated.

To sum up my results, I found that cyanides answered the purpose admirably, but the cost was prohibitory. Sulphur and superheated steam were both good.

I built a plant to treat the dross on a large scale and made a very simple furnace (see sketch) to super-heat the steam and a tube for feeding the pot with chemicals. This furnace is the same as those now in use except that they are now built much larger. So successful was the process that, to protect ourselves, we were obliged to patent it.

As before stated, I wanted to treat the molten metal with superheated steam and also wanted to use the cyanides and the sulphur. Accordingly I devised a method which readily overcame all the difficulties of their application. We all know that potatoes are composed largely of water and that leather scrap is used in making cyanide, so I used a mixture of sulphur, potatoes and leather scrap, and introduced the mixture into the bath by means of an injector like that shown in the accompanying sketch. This could be held under the molten metal and soon became hot enough to generate steam, distil the sulphur, and throw off the gases from the leather. The pot distils all it wants,

the steam keeps the pot boiling, and about fifteen minutes cooks the pot of molten metal.

I have here samples of the dross before melting, after melting and before treating, after treatment; also samples of the finished product and of the residue.

After the pot is boiled it is necessary to allow it to settle awhile, the oxides coming to the top and the new iron and zinc compounds going to the bottom. After it has properly settled, the good metal is bailed into moulds and the residue is dug out with a shovel. The analysis of our refined spelter given below shows it to be nearly equal to the virgin spelter in quality.

	Zinc.	Lead.	Iron.
⟨S⟩ Spelter	98·35	1·50	·15
American Western		1·50	
Average German		1·60	
Silesian		2·10	
Blyberg		1·75	

This analysis of ⟨S⟩ spelter was made from an average of forty car loads.

About this time I became acquainted with the late Colonel Frishmuth, and helped him in his experiments to make aluminium, and began experimenting to ascertain the effects of aluminium when alloyed with zinc. I found that the addition of $\frac{1}{1000}$ part of 1 per cent. of aluminium to zinc was immediately and favorably shown, and it occurred to me that an alloy of zinc and aluminium might be used to advantage in the galvanizing pot, and as a finishing touch in our refining process. The results of these experiments were embodied in patents for use of aluminium in the refining of zinc, and in a patent for the use of aluminium in the galvanizing bath.

The action of the aluminium is, doubtless, to remove the oxygen contained in the molten metal, for when sufficient aluminium is added to make it fluid, and a sample is taken for analysis, no aluminium is found, but any addition after that point is reached is readily detected, and an excess is of no advantage to the metal. Though the quantity used is so small that no action could reasonably be expected, yet it is distributed so quickly all through the mass that in a few

minutes, say, from five to ten minutes, we can commence pouring, while before we used the aluminium it required from one-half hour to two hours for proper settling to take place.

If a sample of untreated metal be taken from the bath, which will not run half way down the mould, it will, upon the addition to it of a little of the aluminium alloy in the ladle, become so liquid that it fills the mould and flows backwards and forwards like water. I have here samples showing this effect.

In using the aluminium I find it best to make an alloy of 98 per cent. zinc and 2 per cent. aluminium, and for the galvanizing bath 5 to 10 per cent. aluminium. So satisfactory have been these results and so commercially practical that we have treated about 100,000,000 pounds of zinc dross by these processes. Even this result was not all we could wish, and, from time to time, as they have suggested themselves, further experiments have been made with varied success.

We found a demand for a better quality of spelter, so we melted our ⟨8⟩ brand and subjected it to the same process a second time, calling it "Double Refined." You will see from the sample shown and the analysis given that the result wished for has been obtained. The analysis shows from 99 to 99·75 per cent. zinc, the only impurity being a little lead.

It was thought that a chemically pure spelter could be made by again refining the "Double Refined," but we were not successful in making it higher than 99·85 per cent. zinc. I then requested my son, Prof. Richards, of Lehigh University, to give his attention to what could be done in refining by the use of electricity, and, after considerable work, we were encouraged to build a plant on a large scale to fully demonstrate its worth. We had a 40 horse-power engine and dynamo, and succeeded in producing large quantities by this means. I believe it was the purest spelter ever made. The following analysis was made from a 2,000-pound sample by Prof. J. W. Richards:

Zinc	99·981
Iron	·007
Aluminium	·002

This electrolytic metal was absolutely free from arsenic or other impurities; its manufacture was not profitable because of the low market value of zinc.

The *scrap zinc* of commerce we melt in our pot furnace and treat in the same manner as the dross, to remove its impurities.

Battery zincs that contain mercury are put in the pot at night. A suitable cover or lid, with condenser and spout, is attached to the pot, by means of which all the mercury is recovered without danger to the workmen.

One other thing I will mention, though a little foreign to my subject. While working with aluminium I discovered a hard alloy which is proving of so much use that I have brought several samples for your inspection. These include scale-beam castings made by Mr. H. Troemner. (I may say that Mr. Troemner has successfully used it, not only for his small balances, but also for the large scales for the mints of Philadelphia and Washington, the New York Treasury and other notable work.) So rigid is the alloy that this beam, which is only intended to bear a weight of 4 ounces, has been tested up to 42 pounds before any appreciable deflection was noticeable. The metal works equally well as the finest brass or bronze under the tool.

In this informal talk I have only touched on the most important and successful work done in this line in the last thirty years.

I thank you for the courtesy that you have extended to me, not only this evening, but at all the meetings of the section at which I have had the pleasure of presiding.

[*To be concluded.*]

Mechanical and Engineering Section.

Read at the stated meeting held Thursday, March 14, 1901.

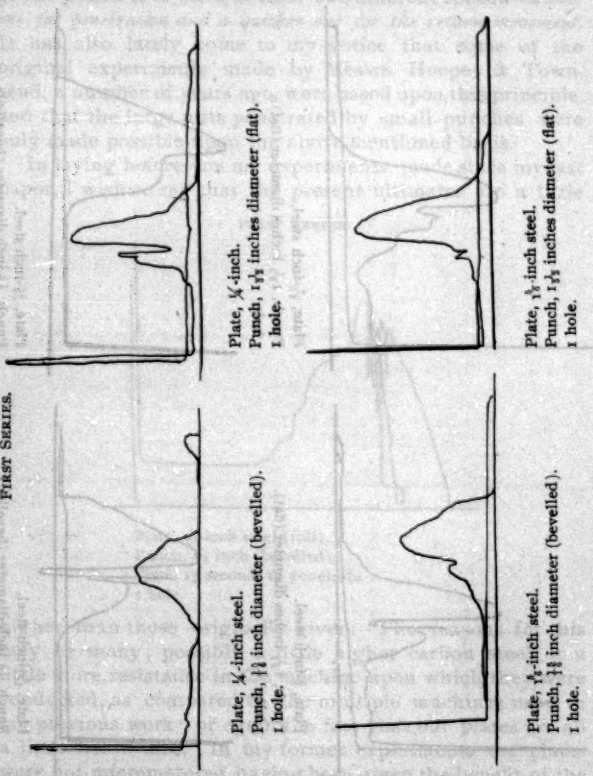
THE FLOW OF METAL.

BY HENRIK V. LOSS, M.E., M.A. Soc. M.E., Member of the Institute.

A little more than a year ago I had the honor and privilege of laying before you a synopsis of a series of experiments on the "Flow of Steel," covering researches made at intervals during the last ten to fifteen years. The Institute was pleased to send out advance copies of my lecture, thereby securing a very thorough and exceedingly interesting discussion. It gave me great pleasure to know that the major points covered by my work found such liberal and hearty reception, and that the only chapter to which any exception was made at that time was the one covering the resistance to punching. Several of the learned members of this section criticised my assertion that the ordinarily accepted and standard ultimate for punching steel should be reduced 30 per cent. or more. I told the members of the section, at the time, that the strangeness of this result came to me originally with as much surprise as it then did to them, and there seemed to be a desire on the part of several of the engineers present during the evening to inaugurate a series of individual and separate experiments, with a view of proving or disproving my statements. The burden of the argument seemed to be that punching could not possibly require less power than shearing. I shall not discuss that aspect of the case to-night, but will confine my arguments to the field of my original assertion, viz., that the accepted power to punch steel is decidedly an unnecessarily large one.

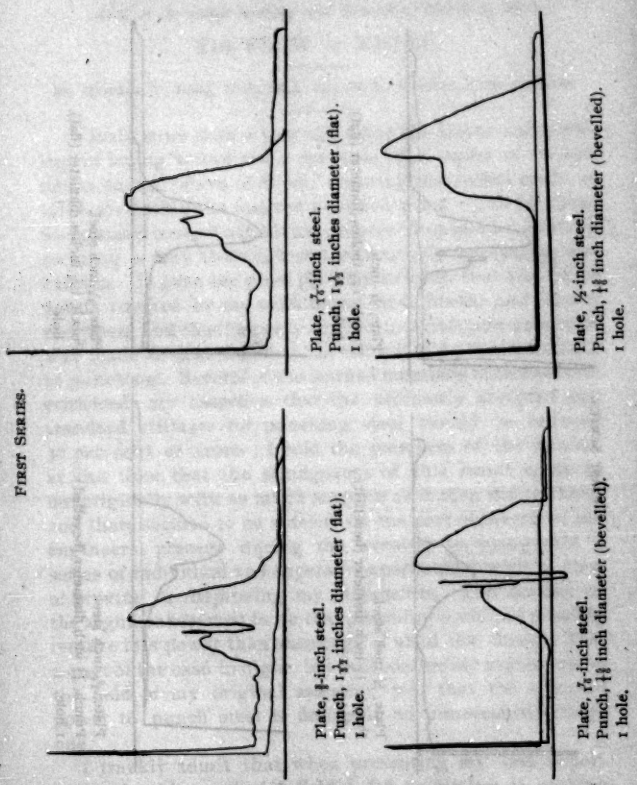
I frankly admit that when presenting my last experiments in this particular field I did so aiming at nothing more than to lay certain new facts before you, having no intention whatever of explaining their causes, as, up to that time, I had not been able to analyze them myself.

This evening, in adding whatever new data I possess, I wish to accompany them with the expression, as my own conviction, that the reason for the low ultimate for punching



lies in the fact that the punching machinery as hitherto used, and with which experiments have formerly been made, were power punches, possessing great speed of penetration,

while the experiments conducted by me have all been confined to hydraulic machines, where the velocity of the flow of metal during the process has been entirely under the

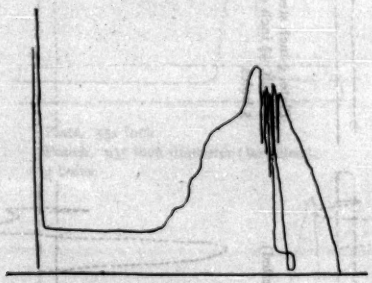


control of the operator. Speaking in a general way, I find from observation that the speed during the actual punching was from three to five and six times as great on a power

machine as on one driven by water pressure, and herein, undoubtedly, lies the solution of the problem. With this in view, it seems to me that the proper way to build a power punch is to have at least two different speeds—a *slow one for penetration and a quicker one for the return movement.* It has also lately come to my notice that some of the original experiments made by Messrs. Hoopes & Townsend, a number of years ago, were based upon this principle, and that the large nuts penetrated by small punches were only made possible upon the above-mentioned basis.

In laying before you my experiments, made since my last paper, I wish to say that the present ultimates are a little

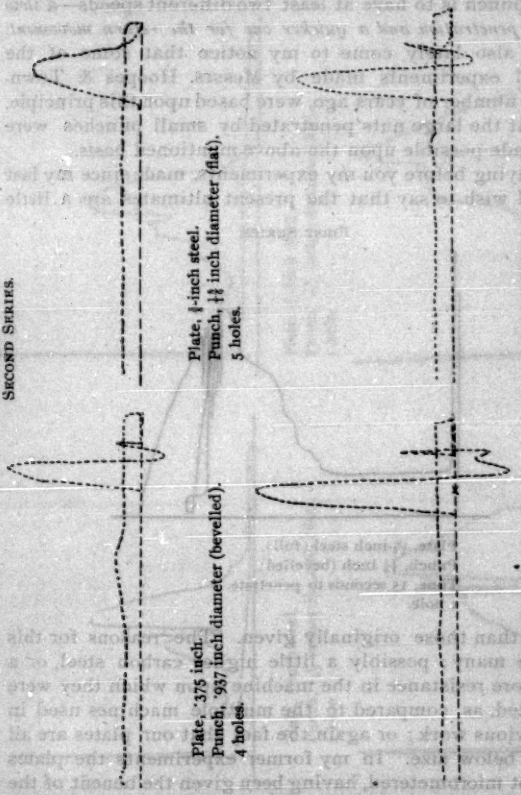
FIRST SERIES.



Plate, $\frac{3}{16}$-inch steel (full).
Punch, $\frac{1}{4}\frac{3}{2}$ inch (bevelled).
Time, 15 seconds to penetrate.
1 hole.

higher than those originally given. The reasons for this may be many; possibly a little higher carbon steel, or a little more resistance in the machine upon which they were conducted, as compared to the multiple machines used in my previous work; or again the fact that our plates are all a little below size. In my former experiments the plates were not micrometered, having been given the benefit of the full round dimension, while with the data given you to-night the sheets have been more carefully measured up. With bevelled punches the original experiments averaged

about 35,000 pounds per square inch, while the data as given on the table below give about 42,000 pounds, increasing with the thickness of the plate. Flat punches gave about

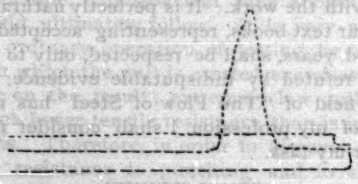


25 per cent. in addition, or about 40,000 to 42,000 pounds for old punches (and somewhat less for new ones), while the present experiments give about 45,000 to 46,000 pounds. It

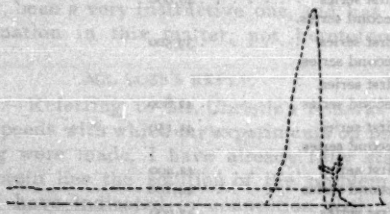
is also seen that with a flat punch the ultimate seems to be nearly constant and not depending upon the dimension of the plate; and, furthermore, it is interesting to note that when $\frac{1}{2}$-inch or $\frac{9}{16}$-inch plate is reached, the effect of the bevelling disappears, the ultimate being the same for both flat and bevelled punches.

This is in perfect harmony with my results found on shearing, which were that with $1\frac{3}{4}$-inch or 2-inch plate the beneficial effect of a bevelled knife disappeared.

SECOND SERIES.



Plate, ·552 inch.
Punch, ·937 inch diameter (bevelled).
3 holes.



Plate, ·552 inch.
Punch, ·937 inch diameter (bevelled).
4 holes.

The ultimate of the steel tested was about 60,000 pounds per square inch, and made by the basic open-hearth process.

I have very little more to say, having confined my work exclusively to meeting your criticisms upon the subject of punching. If any one of you should have conducted any

similar experiments, I should be very much pleased to know the results. I want to give to you to-night, for your own inspection, the original cards upon which the figures are based. They were taken at two different works, both belonging to the Pressed Steel Car Company in Pittsburgh, and conducted by two different men, but, withal, you can see how well they agree. The subject is an important one, as we all know, and when a year or more ago I was confronted by men of your standing and ability taking a strong stand in opposition to the results attained, I felt it my duty to proceed with the work. It is perfectly natural and justly right that our text-books, representing accepted standards for years and years, shall be respected, only to be thrown aside when refuted by indisputable evidence, and if my work in the field of "The Flow of Steel" has merited the recognition of my profession, I shall consider myself fully rewarded for my task.

AVERAGE ULTIMATES.

Thickness of Plate. Inch.		Bevelled Punch. Pounds Per Square Inch.	Flat Punch. Pounds Per Square Inch.
1/4	First series	40,000	49,600
	Second series.		
5/16	First series	39,500	46,000
	Second series.		
3/8	First series.		
	Second series	42,800	30,000 (?)
7/16	First series	41,150	41,000
	Second series.		
1/2	First series	42,400	
	Second series	44,100	38,500 (?)
9/16	First series	45,600	
	Second series	45,750	45,500
	Third series	45,000	

Figures under flat punch for $\frac{3}{8}$-inch and $\frac{1}{2}$-inch material (second series) were taken from a plate which was not micrometered. That they are somewhat lower than the rest may be caused by the character of this special sheet, and also that it may have followed the standard rule of being undersized.

PHILADELPHIA, January 15, 1901.

DISCUSSION.

MR. JAMES CHRISTIE.—It is to be regretted that during the admirable experiments of Mr. Loss, on the flow of metal, especially in those relating to the resistance to punching and shearing, that the element of time was not more accurately denoted.

It is obvious and well known that the resistance to flow or rupture of solid bodies is affected by the velocity of the movement. It has been asserted that if pressures exceeding the elastic limit were applied to material, through a punch for example, and sufficient time allowed, that perforation would ultimately follow. It is very well known that in the ordinary operation of testing by tension, the velocity with which the pull is exerted, exercises an important influence on the result; extremely low pulling speeds showing much lower tensile resistance than is indicated by higher speeds. Therefore, in order to discover exactly the comparative resistance to punching and to shearing, as touched on by Mr. Loss in his earlier paper, uniform velocities of movement should have been obtained as a necessary preliminary. The whole subject as presented by him has, however, been a very instructive one, and has yielded much information in this matter, not heretofore made public.

MR. LOSS'S REPLY.

MR. LOSS:—Referring to Mr. Christie's remarks on the question of speeds with which my experiments on punching and shearing were made, I have already fully stated to-night that herein lies the solution of the problem of low ultimates. I have indicated in connection with my last experiments, and which have been laid before you to-night, the speed of the punching, this being from $\frac{1}{3}$ to $\frac{1}{5}$ of that used in geared power machines.

As to the velocity used in shearing, however, I wish to say that they were practically the same, viz., a little higher for very thin dimensions, becoming slower, even up to the point of stalling the hydraulic press for the greater thicknesses, and in this last instance producing a card similar in effect as the punching card given to you to-night, and to

which card was attached a note, giving fifteen seconds as the time for penetration.

I think, however, that the aim and purpose resulting from my experiments, and to which I wish to call the attention of the Institute, have been misunderstood. I have stated in my paper this evening that the "accepted power to punch steel is decidedly an unnecessarily large one," but have made no criticism regarding the truth or error of results previously found by other investigators in this field.

It is most decidedly the province and duty of the engineer to procure the best and most economic results with the least expenditure, and when it was demonstrated not merely in an experimental or laboratory way, that practical punching machinery can be constructed upon certain principles which will allow them to perform 30 per cent. to 40 per cent. more work with the same expense, the result is one which the engineer certainly ought to heed, and it is this particular aspect of the case to which I want to call the attention of my fellow members of the Institute.

MACHINERY AND THE MAN.*

By ALEXANDER E. OUTERBRIDGE, JR., Member of the Institute

The substitution of automatic or semi-automatic machinery for hand labor in industrial establishments has progressed so rapidly and has attained such large proportions, more especially in this country, during the past few years, that the subject is attracting much attention, and a wide diversity of opinion is expressed by students of industrial economics, employers and others, as to the probable influence of this far-reaching evolution upon the future intellectual development and material welfare of the wage-earner.

An address was recently given by a well-known teacher of economics upon the present aspect of labor in this

*An address to graduating students of the Schools of Drawing, Machine Design, and Naval Architecture, of the Franklin Institute, April 26, 1901.

country, and it was an able exposition of the views of one who has apparently studied the subject mainly from a theoretical and scholastic point of view. According to this authority the extensive substitution of automatic machinery for hand labor, now evident in all trades, is, of necessity, more or less detrimental to the intellectual development of the wage-earner, since the work which he is called upon to perform is reduced to the simplest routine operations involved in feeding a machine with raw material; that the monotony of his task is very depressing, and that the modern system of minute subdivision of labor develops a hopeless feeling in the mind of the operative, because he knows that there is little or no opportunity for him to become a skilled master of any trade through his daily work; that in the old days of the "apprenticeship system," when boys were indentured to masters and taught the principles and practice of a trade, there was more incentive to ambition, and, consequently, a quicker intellectual growth of the young mind, and a keener desire on the part of the youth to become a thorough workman. In a word, we were told that the modern system is injurious to the progress of the wage-earner. This is, perhaps, a natural view for one to take who looks at the subject from a theoretical standpoint only, but daily observation in large industrial works, covering a period of years during which a revolution has occurred in methods of conducting manufacturing industries, has given me a different opinion, based upon a different point of view; moreover, long before the invention of modern automatic machinery, and even before the birth of the factory system, similar views to those which have been given were expressed by the best known writers on economics. In 1776 Adam Smith, in his great work, "The Wealth of Nations," said:

> "They [the working people] have little time to spare for education. * * As soon as they are able to work they must apply to some trade by which they can earn their subsistence. That trade, too, is generally so simple and uniform as to give little exercise to the understanding, while, at the same time, their labor is both so constant and so severe that it leaves them little leisure and less inclination to apply to or even to think of anything else."

The elimination of exhausting manual labor by the substitution of powerful machinery for puny arms has emancipated labor in our day from its hardest tasks, and has given to the worker both inclination and leisure for the development of his intellect in various ways that were impossible under former conditions.

It is not true in point of fact that the operator of a modern labor-saving machine is restricted to the mere feeding of the machine with raw material; he is encouraged and expected to do very much more than this in order to obtain the best results. As an illustration, I may mention a case in point where two men work side by side, tending duplicate machines. One man earns nearly twice the wages of the other, for the simple reason that he can produce in ten hours nearly twice the quantity of finished material, made to standard measurements, the permissible limits of variation being probably but a few thousandths of an inch. The difference in efficiency is in the men, not in the machines.

It is not merely the ability to turn out a maximum amount of work from a modern machine that constitutes a skilled operative. No matter how nearly automatic the machine may be, it is still subject to human guidance, and no matter how nearly perfect its construction, its work is still subject to final correction and control by the hand of the operator. I am satisfied that in all trades where automatic machinery has been extensively introduced for the purpose, it may be, of supplanting hand labor, the ultimate result has proved beneficial to the workers in raising the general average of intelligence, and, furthermore, that it has largely increased the opportunities for labor.

This statement may appear at first sight somewhat paradoxical, but a little examination will, I think, convince you that it follows as a logical sequence. The cheapening of manufactured articles through the aid of machinery enlarges the demand and increases the production to such an extent that those things which were heretofore regarded as luxuries of the rich, soon become ordinary conveniences in the economies of life. This increased production necessitates the employment of a larger number of operatives than were formerly required to make the same articles by hand.

Several years ago a labor-saving machine (an electric travelling crane) was introduced into a certain department of a large manufacturing establishment, and immediately displaced no less than sixty helpers. Since then many other machines of like character have been installed, yet the number of workers in this establishment is more than 50 per cent. greater to-day than before, the total number of wage-earners in these works having risen from a little under 5,000 at the time alluded to, to over 8,000 men at the present time, and the works have grown to be the largest of their kind in the world.

The introduction of labor-saving machinery has proved beneficial to the workers in many other directions. It has shortened the hours of labor; it has improved the sanitary conditions in workshops; it has increased wages; it has increased the purchasing value of wages, and has elevated the social plane of the worker of the present day above that of his predecessors.

Finally, I may say that I believe the opportunities for advancement of the wage-earner in this country are to-day far greater than at any previous time, and that this fortunate condition of affairs is due largely to the educational influence of machinery upon the wage-earner, and to his emancipation from grinding toil by the aid of modern labor-saving machines.

The majority of men holding responsible positions in large industrial establishments to-day have risen from the ranks of the operatives. As a striking illustration I may allude to a remarkable instance, that of a comparatively young man who now stands at the head of the most stupendous industrial corporation the world has ever known, who, twenty years ago, began his work at the bottom of the ladder, and has risen to a position which is entirely unique, being now the central figure in the iron and steel industry of the country, and the president of a corporation with a capital exceeding $1,000,000,000! This is, of course, an extraordinary instance, and is not to be taken as representing an average case, but other illustrations might be given, all tending to show that the substitution of modern labor-

saving machinery for hand-labor has proven to be one of the greatest of all benefits to the wage-earner. The opportunities for lucrative employment and rapid advancement to young men properly equipped, entering the industrial establishments to-day, are greater than at any previous time within my recollection.

ANNUAL REPORTS OF THE DIRECTORS OF THE SCHOOLS OF DRAWING, MACHINE DESIGN, AND NAVAL ARCHITECTURE FOR THE SESSIONS 1900–1901.

THE DRAWING SCHOOL.—It is very gratifying to see the constantly increasing evidences of the usefulness of this school. In these days of large aggregations of capital, consolidation of works, division of labor, interchangeability of parts in manufacture, and the abolition of the apprentice system, a young man of average ability has but little opportunity to learn a trade in any general sense, or to add to his knowledge or secure his own advancement, except by such instruction and information as he can obtain in the evenings, outside and independent of his place of employment. Foremen and superintendents are too busy to assist or instruct their boys, and the work the latter can do, or the position they can fill, is becoming more and more dependent on their own energy and push and on their taking advantage of the opportunities offered by night schools, and less on the experience they can gain in their daily work. They may become very expert in the latter, but the very skill thus acquired makes them so valuable in that capacity that it chains them to that one thing.

A knowledge of the geometry, technicalities and conventionalities of drawing is so fundamentally essential to all industries that it should be the very first thing for the young man to obtain, and it is pleasing to see the increasing appreciation on their part of this fact. This knowledge once attained leads to a desire for mathematics, design, and special construction, and thus the technical education is built up.

The school has been large and well attended, and is maintaining and increasing its reputation, the credit for which is largely due to the instructors, Messrs. Clement Remington, Oscar Mowry, Albert F. Griffith, John Rae, and W. W. Twining.

WM. H. THORNE,
Director.

THE FOLLOWING STUDENTS ARE ENTITLED TO HONORABLE MENTION:

In the Senior Mechanical Class.

Frederick Schwartz,	Frank Stoertz,
Clarence Fithian,	William J. Borton,
Joseph Roberts,	E. Winfield Finkbiner,
Gustavus K. Focke,	Henry Noske,
Theodore R. Johnson,	Henry Hobdell,
A. K. Graham,	Luther Krout.

In the Intermediate Mechanical Classes.

Herman J. Ruch, William J. McFarland,
James Anderson, Jr., J. J. McGill,
Edwin D. Bates, E. L. Buckwalter,
Frederick Hartmeyer, Bernard G. Smith,
Richard Pockert, Julian Harwood,
Charles F. Miller, Fred. W. Wiegand.

In the Junior Mechanical Classes.

Seward G. Dobbins, John Marshall,
Harry Hartranft, E. H. Berry,
William T. Sellner.

In the Architectural Class.

Duffield Ashmead, Jr., John L. McGarvey,
Samuel Miller.

In the Free-Hand Class.

Alfred G. Rose, Roy E. Blithe,
Benjamin Feldman.

THE FOLLOWING STUDENTS ARE AWARDED SCHOLARSHIPS FROM THE B. H. BARTOL FUND, ENTITLING THEM TO TICKETS FOR THE NEXT TERM:

Walter C. Chadwick, Harry H. Appleton,
L. Hastings Alexander, Frank B. McDowell,
J. W. Shaffer, Roger W. Peterson.

THE FOLLOWING STUDENTS, HAVING ATTENDED A FULL COURSE OF FOUR TERMS, ARE AWARDED CERTIFICATES:

Frank E. Mahon, E. Winfield Finkbiner,
John Limprun, Frederick Schwartz,
Clarence Fithian, Edward J. Rowland,
Gustavus C. Focke, Henry Noske,
Frank Stoertz, Charles Weinerth,
Herman Gutsche, Arthur G. Reinhilt,
A. K. Graham, J. B. Stevenson, Jr.,
Harry Hobdell, Luther Krout,
William J. Borton.

The Germantown Junction Branch School, under the direction of Mr. Haakon Nortom, exhibits very satisfactory progress, and a large increase in the number of pupils. The following students are awarded certificates:

Edwin Kean Fagan, Malcolm L. Baker,
Louis Ehlinger, Walter Andrews,
Spencer Ogborn, Frederick A. Steck.

THE SCHOOL OF MACHINE DESIGN.—The extension of the scope of the School of Elementary Mathematics to embrace subjects in a course in machine design has proved a very satisfactory step. The students who now

undertake the mathematical work offered, do so with a definite aim in view, instead of being left to their own resources after this is completed and, in consequence, evince a lively interest even in this preliminary work.

The subjects comprising the course in machine design proper are offered not merely as a feeder to the course in mathematics, but for their own intrinsic value to those who are interested in the design and construction of machinery, and no effort has been spared to make them of practical value and to present them in a logical and systematic manner. Indeed, the subjects, analytical mechanics and strength of materials, have been treated with unusual thoroughness for a course in which no higher mathematics is used, and many theorems, usually taken for granted in elementary works on these subjects, have been satisfactorily proved by the aid of special methods. It is unfortunate, in connection with this course, that the Institute does not possess the necessary laboratory equipment for carrying on tests of the strength of materials and of the efficiency of transmission devices; laboratory training of this kind being of undoubted value to the designer.

Next year the course is to be carried on substantially as already outlined and the only material change in view may be the cutting out of some of the work in mechanics and the addition to that in the strength of materials.

That the school bids fair to well serve its purpose, there seems very little doubt, if the interest shown by the students and their progress are an indication.

LUCIEN E. PICOLET, *Director.*

THE FOLLOWING PUPILS ARE AWARDED CERTIFICATES:

Charles Stone, William Williams,
Herbert E. Ives.

THE SCHOOL OF NAVAL ARCHITECTURE.—The School of Naval Architecture had, during the first half-term, thirty-one students, and during the second half-term twenty-five students. Six of these have attended the full term of two years, and will be graduated at the end of this term. The attendance at the lectures each week has always been up to the maximum.

The Senior Class has studied and examined all kinds of general arrangements and the details of fittings for same, and completed the necessary calculations that are required for the proper and efficient design of any vessel. They have made themselves proficient in the use of the integrator, estimating costs, calculating weights of material and centres of gravity, strength of structure of the hull under different conditions, as well as the powering of ships. Their home-work has shown wonderful energy, considering that the drawings, etc., are made without the help of the usual adjuncts of a drawing office. In fact, the graduating class has exhibited more than ordinary intelligence, and its members are neat and careful draughtsmen, zealous and painstaking.

The Junior students have progressed rapidly in both theoretical and practical naval architecture, and have also shown marked zeal in their work both in class and home work, numerous drawings and tracings having been made from blue prints which are beyond the average in neatness and accuracy.

A. J. MACLEAN,
Director.

THE FOLLOWING STUDENTS ARE AWARDED CERTIFICATES:

William H. Balla,	Fred'k Austin Coolidge,
Gabriel Hofgaard,	James A. Kelley,
Henry J. Hack,	Joseph Rilatt.

BOOK NOTICES.

Report of the Geological Survey of North Dakota. (First biennial report.) By E. J. Babcock, State Geologist, Grand Forks, N. D. State Print. 1901. 8vo. Pp. 101, with numerous illustrations.

This is the first official contribution from the lately established Geological Survey of North Dakota, and the author wishes it to be regarded as a preliminary bulletin. It deals with the topography and geology, the clays of economic value, the coal deposits, and the water supplies of the State. W.

Experiments Arranged for Students in General Chemistry. By Edgar F. Smith (Professor of Chemistry, University of Pennsylvania), and Harry F. Keller (Professor of Chemistry, Central High School, Philadelphia). Fourth Edition. Enlarged with forty-one illustrations. Philadelphia: P. Blakiston's Son & Co. 1900. 12mo. Pp. 88. (Price, 60 cents.)

The plan of this work consists in the formulation of a progressive series of experiments in general inorganic chemistry, with problems appended, under each head, to accompany the regular course of class instruction.

The present edition (the fourth) has been improved by the introduction of new experiments, the modification of others described in the former editions, and a general revision of the text. W.

Analyse Chimique et Purification des Eaux Potables. Par P. Guichard, Membre de la Société Chimique de Paris, etc.

L'Industrie des Matières Colorantes Azoiques. Par George F. Joubert, Docteès-Sciences, etc. Paris: Gauthier-Villars, Masson et Cie. (Price, 2.50 francs in paper, 3.00 francs, pasteboard covers.)

These contributions to the valuable technical series issued by the publishers under the general title, "Encyclopédie Scientifique des Aide-Mémoire." Each is edited by an acknowledged expert, and concisely cover the subjects which are treated. W.

Traction and Transmission. A monthly supplement to *Engineering*. London, Eng. Vol. I. No. 1. April, 1901. (Price, 2 shillings net.)

The publishers of *Engineering* have issued the first impression of a monthly supplement to their widely-known journal, to be devoted to subjects relating to traction and power transmission. The new publication is issued in quarto form, and comprises fifty-six pages with numerous illustrations admirably printed on heavy paper in large type. The subjects treated are all useful contributions of a high order of merit. W.

Traité de la Fabrication des Liqueurs et de la Distillation des Alcools. Par P. Duplais aîné. Septième édition, entièrement refondue par Marcel Arpin, Chemiste industriel, et Ernest Portier, Répétiteur de Technologie agricole à l'Institut agronomique. Deux Volumes in-8 vendus séparément. 1900. Tome I: Les alcools. Volume de viii-613 pages avec 68 figures, 8 fr. Tome II: Les liqueurs. Volume de 606 pages avec 69 figures, 10 fr. Paris: Librairie Gauthier-Villars.

The present edition of this work has been completely revised by the editors and includes the latest advances in the technology of the manufacture of alcohol and liqueurs. Volume I exhibits the present state of our knowledge of alcoholic fermentation, with an exposition of the chemical and microbiological facts lying at the foundation of the art and the description of the various methods of distillation.

Volume II is devoted to the art of manufacturing these special products of the distiller which are known collectively as "liqueurs." W.

General Map of the Anthracite Coal Fields of Pennsylvania. Compiled under the direction of the Chief of the Division of Mining and Mineral Resources, U. S. Geological Survey. By Wm. W. Ruley, Chief of Bureau of Anthracite Coal Statistics, Philadelphia. Washington: Government Print, 1901.

This publication embraces a sketch map showing the local distribution of the three important anthracite coal fields of Pennsylvania—the Schuylkill, Lehigh and Wyoming fields; a table giving the figures of production of each field by years from 1820 to 1900, inclusive, and a graphical chart indicating the production by fields and the total output for the same period. W.

Electric Lighting. A practical exposition of the art for the use of engineers, students, and others interested in the installation or operation of electrical plants. Vol. II. Distributing System and Lamps. By Francis B. Crocker, E.M., Ph.D, Professor of Electrical Engineering in Columbia University, New York, etc. (Large 8vo, pp. vi–505.) New York: D. Van Nostrand Company: London. E. & F. N. Spon. 1901. (Price, $3.00.)

In his preface to this volume, the author, who is a well-known electrical engineer and teacher, explains that the work relates to the conductors for transmitting and distributing the current to the lamps and to the various auxiliary devices—switches, cut-outs, meters, etc.—employed with the same. The first half of the book, lately noticed, is devoted to the generating plants.

The first half of the present book is devoted to the properties of conductors and various systems of distribution, including direct current, as well as single and polyphase currents. Following this are chapters on overhead and underground conductors, arc lamps, interior wiring, incandescent and other forms of lamps, and electric meters.

There are two Appendices. The first gives in full the "National Electrical Code," containing the requirements according to which all electric lighting and other installations should be made, and the second gives the report in full of the Committee on Standardization of the American Institute of Electrical Engineers.

The book is printed in good style and is provided with an excellent index. W.

Handbuch der chemischen Technologie in Verbindung mit mehreren Gelehrten und Technikern bearbeitet und herausgegeben von Dr. A. P. Bolley und Dr. K. Birnbaum. Nach dem Tode der Herausgeber fortgesetzt von Dr. E. Engler, Geh. Hofrath und Professor der Chemie an der technischen Hochschule in Karlsruhe. Ersten Bandes dritte Gruppe. Die chemische Technologie der Brennstoffe. Von Dr. Ferdinand Fischer, Professor an der Universität in Göttingen. Braunschweig: Verlag von Friederich Vieweg u. Sohn. 1901. (Price, 15 marks.)

The volume above entitled forms one of the extensive series of "Bolley's Technologie," which for several years has issued from the press of Vieweg & Son, and which is widely known among chemists everywhere as an encyclopædic work on chemical technology of the highest order of excellence, compiled with the exhaustive thoroughness which usually characterizes German works of its class.

The volume is devoted to artificial fuel (briquettes), coke ovens, water gas, producer gas and mixed gases, and gas furnaces. The volume has 370 illustrations. W.

Technical Gas Analysis. By Frank H. Bates. (The Industrial Gas Series.) Vol. I. Philadelphia: Philadelphia Book Company. 1901. (Price, $1.00.)

This is the first volume republished in book form, of a series of articles on industrial gases, which appeared originally in the *Journal of Electricity*. The volume is intended by the author to serve as a guide in the selection of the best method and apparatus for use in making analyses of gases of varying composition—such as blast furnace gases, producer gases, flue gases, illuminating and other gases used for power purposes. The seven chapters of the book are devoted respectively to the collection of samples, methods of gas analysis, the Orsat apparatus, the Elliott apparatus, the Hempel apparatus, measurement of gases, and the properties of gases and preparation of reagents employed. W.

Tunneling. A practical treatise. By Charles Prelini, C. E., with additions by Charles S. Hill, C. E., Associate Editor *Engineering News*. 150 diagrams and illustrations. 8vo, pp. vi + 311. New York: D. Van Nostrand & Co. 1901. (Price, $3.00.)

This work has been prepared, as the author states, to meet the need of a text-book in the English language that would be suitable for use by engineering students. The large works of Drinker and Simms, while admirable expositions of the art and valuable for reference, are obviously unsuited for the purpose contemplated by the author, and he has accordingly sought to embrace in a work of convenient size and moderate price, an explanation of the various operations that are required in tunneling, with illustrations, by suitable examples, of the actual application of these methods in practice. W.

Report on the Census of Cuba. 1899. Lt.-Col. J. P. Sanger, Inspector-General, Director Henry Gannett, Walter F. Willcox, Statistical Experts. Washington: Government Print. 1900. 786 pp. 8vo, with numerous illustrations.

Those of our citizens in need of reliable statistical data concerning the Island of Cuba, its geography, history, population, agricultural and mineral resources, will find this publication a valuable compendium of information. W.

Franklin Institute.

[*Proceedings of the stated meeting held Wednesday, May 15, 1901.*]

HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, May 15, 1901.

Vice-President WASHINGTON JONES in the chair.

Present, 96 members and visitors.

Additions to membership since last month, 21.

In connection with the several amendments to the By-Laws of the Institute, proposed at the stated meeting of April 17th, affecting the question of the annual dues of the contributing members, the Actuary reported the following resolution passed by the Board:

"RESOLVED, that the Board of Managers deems it inexpedient at this time to suggest any changes in the dues of members of the Institute, especially any changes that might reduce the revenues, which at this time are inadequate to meet current expenses, and recommends that action upon the amendments be indefinitely postponed."

On motion the resolution was adopted and the recommendation therein contained was approved.

The Secretary presented communications from His Honor the Mayor of Boston, respecting the proposed foundation of a Franklin Institute in Boston, with the proceeds of the Benjamin Franklin Fund; also a communication from the Verein Deutscher Ingenieure in reference to the proposition for the preparation of a technical dictionary in English, French and German, to the preparation of which the Franklin Institute has agreed to contribute; also a letter from Prof. Arthur Beardsley, acknowledging his election as an honorary member of the Franklin Institute.

Mr. Morris Earle presented a description, with illustrations, of the electrical equipment of the physiological laboratory of the Jefferson Medical College, Philadelphia.

Discussed by Professor Rondinella and the author.

The subject was, on motion, referred to the Committee on Science and the Arts.

Mr. John S. Forbes described his apparatus for sterilizing water and exhibited the same in operation.

Mr. R. M. Walsh, of Janvier, N. J., exhibited and described his method of manufacturing "aventurine" glass in large masses suited for mantle-pieces, table-tops, etc.; an entirely new industry. The subject was referred to the Committee on Science and the Arts.

Mr. Fred. E. Ives exhibited and described the Chapman-Jones photographic plate tester, and likewise a novel form of lantern polariscope of his devising.

On motion, both subjects were referred to the Committee on Science and the Arts.

The Secretary made some reference to the death of the late Actuary of the Institute, David Shepard Holman, and on motion, the chairman was authorized to name a special committee to prepare a memorial of the deceased.

Adjourned.

WM. H. WAHL, *Secretary.*

COMMITTEE ON SCIENCE AND THE ARTS.

[*Abstract of proceedings of the stated meeting held Wednesday, May 1, 1901.*]

MR. LOUIS E. LEVY in the chair.

The following reports were presented for final action, and were approved:

(No. 2016.) *The Diesel Motor.*—Rudolph Diesel, Munich, Bavaria.

ABSTRACT.—The report contains a brief historical sketch of the development of the internal combustion engine, of which type the Diesel Motor is the latest and most advanced representative; then proceeds to describe the special features of Herr Diesel's invention in respect of construction and operation; then gives the results of various tests of the engine, some of which were participated in by members of the investigating committee. The report is reserved for publication in full.

The award of the Elliott Cresson Medal is made to the inventor. [*Sub-Committee.*—Henry Harrison Supplee, Chairman; Arthur Falkenau, Coleman Sellers, Wilfred Lewis, Arthur M. Greene, Jr.]

(No. 2155.) *Chester Steel Tie for Railway Tracks.*—Philadelphia, Pa.

ABSTRACT:—This device consists of an inverted tie-bar of suitable weight and section, and for standard gauge tracks, 6 feet long. Near each end, the upper edge of this bar is slotted or notched out to receive the base of the rail, the outer edge of the notch being hook-shaped so as to fit over the flange of the rail. These two notches determine the gauge of the track. Immediately under each notch is placed a bearing-plate or chair consisting of a steel plate ¼ inch to ¾ inch thick, 12 inches wide and 20 inches long, bent down at the ends forming inclined legs, about 5 inches long. These bearing-plates are slotted out so that the tie or gauge-bar can slip through them freely, and two cheek pieces or clips are stamped up from the under side, for the purpose of engaging with the inner base flange of the rail. No other fastenings of any kind are used.

In laying the tracks, it is only necessary to distribute the ties along the roadbed with the bearing-plates or chairs clipped towards the center of the track far enough to permit the rails to be placed in the notches of the gauge bars. When the rails are in position the bearing-plates are pushed out until the clips engage the inner flanges of the rail and the track is ready for tamping. The ballast alone is depended upon for holding the bars in position, the shape of the bearing-plates, it is claimed, being such as to insure this result.

The report admits the device to be simple in construction and ingenious in design, but states the following objections to its practicability, viz.:

The difficulty of opening and closing the gauge around curves without a special set of ties for each curve; the difficulty of securing the track at switches and crossings; of maintaining an accurate gauge owing to variations in the flanges of the rails and the wear in the notches; the necessity of supplying new ties for every change of rail section; the difficulty in taking out and replacing rails; and lastly the impossibility of keeping the clamping devices tight under heavy and fast traffic. [*Sub-Committee.*—Thomas P. Conard, Chairman; Henry F. Colvin, Charles Day, E. H. Johnson].

National Cash Register.—National Cash Register Company, Dayton, O.

ABSTRACT.—This apparatus in its present form is the subject of a large number of patents, many of them covering minor details of construction, and the present machine is the product of many minds.

The first machine was not a register at all, consisting simply of a set of pivoted levers with the numbered finger-piece at one end and the indicator at the other; no record being made.

The next step was to add a simple counter for each key and the amount was found by multiplying the number on the key by the number of times the counter showed it to have been depressed.

This was found to be troublesome, and counters were applied to each key, showing the amount credited thereon. This necessitated the taking off of these amounts on a slip and afterwards adding them to prove the cash in the drawer, and was done away with by attaching a "total adder" device, showing the whole amount at a glance.

These machines are operated by keys and the register is actuated by a spring motor.

The arrangement in construction has been improved from time to time, to prevent dishonest use, as practice has shown points of weakness until the outgrowth is the present machine.

For example: means were adopted to make a full depression of the keys necessary to full operation and to prevent improper registration in case the pressure ceased before full depression and was completed by a second pressure; also, means for locking the keys until the drawer was closed after each transaction.

The most approved type of the machine is actuated by a crank and uses depressable buttons (without levers) arranged in outwardly-curved columns, one to each indicating disk, duplicated to show any amount in dollars and cents and mechanically connected to the total adder.

A printing device is added which prints and throws out a check and also makes a record upon a slip. Means are provided for stopping the check, if desired, and printing upon the slip only, the difference in the intensity of the ink indicating no check. Should a clerk operate the apparatus and fail to give a customer a check, the slip tells on him.

These machines are furnished with a set of lettered buttons, each salesperson being designated by a certain letter and other buttons indicating the character of the transaction. For operation, the buttons indicating the amount of the purchase are first depressed, then the one showing the character of the transaction, then the letter showing the salesperson. This latter must be done. The machine is now set and the crank is turned one revolution, operating the indicators and registers and releasing the buttons, leaving it ready for the next transaction.

Other details devised to render more difficult the improper use of the machines for dishonest purposes are referred to in the report, but the principal items of the construction of the modern machine are noted in what has preceded.

The report concludes with the statement that "the registers fill the requirements of such an appliance thoroughly and are adapted to meet the necessities of all commercial business." The award of the John Scott legacy

Premium and Medal is recommended to be granted to F. J. Patterson, J. H. Patterson, Thos. Carney and Hugo Cook, the inventors of the more important features of the machine. [*Sub-Committee.*—Geo. S. Cullen, Chairman; Chas. Day, Lucien Picolet, W. C. L. Eglin.]

Waterhouse-Forbes Sterling Method and Apparatus.—Addison G. Waterhouse and John S. Forbes, of Philadelphia.

This report is reserved for publication in full. The award of the Elliott Cresson Medal is recommended. [*Sub-Committee.*—A. C. Abbott, M.D., Chairman; H. W. Spangler, Harry F. Keller, Philip Pistor.]

The following reports passed first reading:

(No. 2113.) *Liszt Organs.*—Mason & Hamlin Co., Boston, Mass.

(No. 2134.) *Improvements in Musical Instruments.*—Charles F. Albert, Philadelphia.

(No. 2166.) *Researches in Experimental Phonetics.*—E. W. Scripture, New Haven, Conn.

(No. 2167.) *Color Sense Tester.*—E. W. Scripture, New Haven, Conn.

(No. 2175) *Balance for Testing White-Metal Alloys.*—Joseph Richards, Philadelphia.

(No. 2178.) *Micrometer Rolling-Mill Plate Gauge.*—Robert B. Haines, Philadelphia.

The following applications were dismissed for cause, without prejudice against renewal:

(No. 2153.) *Apparatus for Liquefying Aëriform Gases.*—M. Berger and O. P. Ostergren, New York.

(No. 2172.) *Wireless Telegraphy.*—G. Marconi, New York.

Awards in the cases of reports No. 2161 (subject: The Standard Voting Machine), and No. 2168 (subject: The Bardwell Votometer) were increased, on reconsideration, to a recommendation of the grant of the John Scott Legacy Medal and Premium in each case.

The special committee appointed to prepare and recommend a practicable system for indexing the committees' reports, through its Chairman, Mr. J. Logan Fitts, presented a report which, with its accompanying recommendations, was adopted, and the Secretary was directed to carry the same into effect upon receiving assurance that the Board of Managers would supply the needful funds for the purpose. W.

SECTIONS.

Abstracts of Proceedings.

PHYSICAL SECTION.—*Stated Meeting*, held Wednesday, April 24th, at 8 P.M Dr. Geo. F. Stradling in the chair.

Prof. Wilbur M. Stine made the first communication on "E. H. Lenz, as one of the Founders of the Science of Electro-magnetism." Discussed by Messrs. Stradling, Landis, Hoadley and Pawling. Prof. Eric Doolittle, of the Flower Observatory, University of Pennsylvania, gave an interesting contribution on "Double-Star Astronomy." Discussed by Messrs. Hoadley, Landis, Stradling and Lloyd.

The chairman made a suitable allusion to the loss which physical science had sustained by the recent death of Prof. Henry A. Rowland.

JESSE PAWLING, JR.,
Secretary.

CHEMICAL SECTION.—*Stated Meeting*, held Thursday, April 25th. Dr. W. J. Williams in the chair. Present, 19 members and 2 visitors.

The paper of the evening was read by Dr. Robt. H. Bradbury, on "Some of the Researches of Professor Spring, of Liège." Discussed by Dr. Henry Leffmann, Dr. Harry F. Kebler, Dr. Wm. H. Wahl, Mr. Joseph Richards and others.

Dr. Keller called attention to the special value of such *resumés* as that which Dr. Bradbury had presented at this meeting, and, on his motion, the speaker of the evening was given a vote of thanks for his interesting and valuable communication.

W. H. WAHL,
Secretary pro tem.

SECTION OF PHOTOGRAPHY AND MICROSCOPY.—*Stated Meeting*, held Thursday, May 2, 1901. Dr. Chas. F. Himes in the chair. Present, 49 members and visitors.

Mr. F. V. Chambers inquired concerning the status of the resolution passed at the previous meeting requesting the official sanction of the Board of Managers of the Institute for the holding of the proposed photographic exhibition, Mr. Chambers was informed that the Board had as yet taken no action.

The chairman made some remarks explanatory of the condition of the plans for instituting a system of photographic record work by the section which had been in charge of the Executive Committee. He then made an informal address on the subject, suggesting some directions in which the Institute might do useful work of this kind.

Mr. F. E. Ives gave a description of a new lantern polariscope of his devising, which had the advantage of permitting the object to be laid flat upon the object stage, and also of permitting the instrument to be used for rendering lantern projections if desired without change except the interposition of a shutter. The speaker gave some interesting illustrations of the device.

Dr. Himes described and exhibited an exposure scale with a portable actinometer, the latter being an extremely compact and convenient device.

The same speaker likewise described and exhibited the Lothian stereoscope. This instrument is adjustable for interocular distance, which adds greatly to its efficiency. He likewise called attention to the superiority of the green ammonio-citrate of iron over the brown salt commonly used in the making of blue-prints, the first-named salt being much more rapid in its operation.

A resolution was adopted authorizing the President of the Section to appoint a special committee of five members to devise and report a plan of "Photographic Record Work."

WM. H. WAHL,
Secretary pro tem.